PB-238 464

# DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE SECONDARY ALUMINUM SMELTING SUBCATEGORY OF THE ALUMINUM SEGMENT OF THE NONFERROUS METALS MANUFACTURING POINT SOURCE CATEGORY

ENVIRONMENTAL PROTECTION AGENCY

MARCH 1974

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U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET

1. Report No. EPA-440-1-74-019-e

2.

**PB 238 464**

4. Title and Subtitle Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Secondary Aluminum Smelting Subcategory of the Aluminum Segments of the Nonferrous Metals Manufacturing Point Source Category.

5. Report Date March 1974

6.

7. Author(s) George S. Thompson, Jr.

8. Performing Organization Rept. No. EPA-440-1-74-019-e

9. Performing Organization Name and Address

Environmental Protection Agency
Effluent Guidelines Division
WSM-E, Rm. 913, WH-452
Washington, DC 20460

10. Project/Task/Work Unit No. NA

11. Contract/Grant No. 68-01-1518

12. Sponsoring Organization Name and Address Same as #9.

13. Type of Report & Period Covered Final

14.

15. Supplementary Notes

16. Abstracts This document presents the findings of an extensive study by the Environmental Protection Agency of the secondary aluminum smelting industry for the purpose of developing effluent limitations guidelines and standards of performance to implement Sections 304, 306, and 307 of the Federal Water Pollution Control Act, as amended.

Effluent limitations guidelines are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available" and the "Best Available Technology Economically Achievable" which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The "Standards of Performance for New Sources" set forth a degree of effluent reduction which is achievable through the application of the best available demonstrated control technology processes, operating methods or other alternatives.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

17c. COSATI Field/Group

**PRICES SUBJECT TO CHANGE**

18. Availability Statement GPO, Washington, DC

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 132

22. Price $3.70/2.25

# DEVELOPMENT DOCUMENT

# for

# EFFLUENT LIMITATIONS GUIDELINES

# and

# NEW SOURCE PERFORMANCE STANDARDS

# for the

# SECONDARY ALUMINUM SMELTING SUBCATEGORY of the ALUMINUM SEGMENT of the NONFERROUS METALS MANUFACTURING POINT SOURCE CATEGORY

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# ABSTRACT

This document presents the findings of an extensive study by the Environmental Protection Agency of the secondary aluminum smelting industry for the purpose of developing effluent limitations guidelines and standards of performance to implement Sections 304, 306, and 307 of the Federal Water Pollution Control Act, as amended.

Effluent limitations guidelines contained herein set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best available technology economically achievable which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The standards of performance for new sources contained herein set forth the degree of effluent reduction attainable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The development of data and recommendations in this document relate to waste waters generated in metal cooling, fume scrubbing and wet residue processing. The best practicable control technology currently available, the best available technology economically achievable, and the best available demonstrated control technology for each of these waste water streams are presented in Section II of this report. The effluent limitations and standards of performance corresponding to these technologies also are presented.

Supporting data and rationale for development of the effluent limitations guidelines and standards of performance also are contained in this report.

# CONTENTS

| Section | | Page |
|---|---|---|
| I | CONCLUSIONS | 1 |
| II | RECOMMENDATIONS | 3 |
| | Best Practicable Control Technology Currently Available | 3 |
| | Best Available Technology Economically Achievable | 5 |
| | Best Available Demonstrated Control Technology | 5 |
| III | INTRODUCTION | 9 |
| | Purpose and Authority | 9 |
| | Methods Used for Development of Effluent Limitations Guidelines and Standards of Performance | 9 |
| | General Description of the Secondary Aluminum Industry | 12 |
| IV | INDUSTRY CATEGORIZATION | 17 |
| | Introduction | 17 |
| | Objectives of Categorization | 17 |
| | Definition of the Industry | 17 |
| | Process Description | 17 |
| | Industry Categorization | 28 |
| V | WASTE CHARACTERIZATION | 39 |
| | Introduction | 39 |
| | Specific Water Uses | 39 |
| VI | SELECTION OF POLLUTANT PARAMETERS | 57 |
| | Introduction | 57 |
| | Rationale for the Selection of Pollutant Parameters | 57 |
| | Rationale for Rejection of Other Waste Water Constituents as Pollutant Parameters | 64 |
| VII | CONTROL AND TREATMENT TECHNOLOGY | 67 |
| | Introduction | 67 |
| | Waste Water from Metal Cooling | 67 |
| | Waste Water from Fume Scrubbing | 71 |
| | Waste Water from Residue Milling | 84 |

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## CONTENTS (continued)

| Section | | Page |
|---|---|---|
| VIII | COSTS, ENERGY AND NONWATER QUALITY ASPECTS | 89 |
| | Introduction | 89 |
| | Basis for Cost Estimation | 89 |
| | Waste Water from Metal Cooling | 90 |
| | Waste Water from Fume Scrubbing | 94 |
| | Waste Water from Residue Milling | 96 |
| IX | BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE--EFFLUENTS LIMITATIONS GUIDELINES | 101 |
| | Introduction | 101 |
| | Industry Categorization and Waste Water Streams | 101 |
| | Waste Water from Metal Cooling | 102 |
| | Waste Water from Fume Scrubbing | 104 |
| | Waste Water from Residue Milling | 108 |
| X | BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE--EFFLUENTS LIMITATIONS GUIDELINES | 111 |
| | Introduction | 111 |
| | Waste Water from Metal Cooling | 112 |
| | Waste Water from Fume Scrubbing | 112 |
| | Waste Water from Residue Milling | 115 |
| XI | NEW SOURCE PERFORMANCE STANDARDS | 117 |
| | Introduction | 117 |
| | Waste Water from Metal Cooling | 117 |
| | Waste Water from Fume Scrubbing | 118 |
| | Waste Water from Residue Milling | 119 |
| XII | ACKNOWLEDGMENTS | 123 |
| XIII | REFERENCES | 125 |
| XIV | GLOSSARY | 127 |

# FIGURES

| Number | Title | Page |
|---|---|---|
| 1 | Location of Secondary Aluminum Smelters | 15 |
| 2 | The Total Secondary Aluminum Process | 18 |
| 3 | Recirculated Cooling Water System | 69 |
| 4 | Schematic Diagram of Elements of the Derham Process | 72 |
| 5 | Chloride Fume Scrubber Waste Water Treatment (Neutralization-Settling) | 81 |
| 6 | Chloride Fume Scrubber Treatment (Partial Recycle and Evaporation Pond Discharge) | 82 |
| 7 | Aluminum Fluoride Fume Scrubber System with Continuous Recycle | 83 |
| 8 | Residue Milling and Alkaline Chloride Fume Scrubber Waste Water Treatment System | 86 |
| 9 | Capital Cost for Control and Treatment of Metal Cooling Water | 93 |

# TABLES

| Number | Title | Page |
|---|---|---|
| 1 | Effluent Limitations for Treated Fume Scrubber Waste Water Generated During Chlorine Demagging to be Achieved by July 1, 1977 | 4 |
| 2 | Effluent Limitations for Treated Waste Water from Residue Milling to be Achieved by July 1, 1977 | 6 |
| 3 | Summary of Features of Plants Visited | 11 |
| 4 | Production of Aluminum Alloys by Secondary Smelters (1970 & 1971) | 14 |
| 5 | A.S.R.I. Aluminum Scrap Classifications | 20 |
| 6 | Consumption of New and Old Scrap in the United States in 1970 and 1971 by Secondary Smelters | 22 |
| 7 | Secondary Aluminum Smelters A. Those Claiming No Process Water Use | 29 |
| 8 | Secondary Aluminum Smelters B. Smelters Using Water for Ingot Cooling Only | 30 |
| 9 | Secondary Aluminum Smelters C. Water Used for Scrubbing and/or Cooling | 33 |
| 10 | Secondary Aluminum Smelters D. Water Used for Dross Processing, Scrubbing and/or Cooling | 35 |
| 11 | Cooling Water Disposal Practices | 41 |
| 12 | Cooling Water Usage by Secondary Smelters | 41 |
| 13 | Character of Cooling Waste Water (Plant C-7) | 42 |
| 14 | Character of Cooling Waste Water (Plant D-6) | 43 |
| 15 | Character of Cooling Waste Water (Plant B-11) | 44 |
| 16 | Fume Scrubbing Waste Water - Generation and Disposal Practices | 46 |
| 17 | Quantities of Waste Water Generated in the Wet Scrubbing of Chlorination Fumes | 47 |
| 18 | Character of Waste Water from Chlorination Fume Scrubbing (No Treatment) | 48 |
| 19 | Residue Waste Water Generation and Disposal Practices | 51 |

TABLES (continued)

| Number | | Page |
|---|---|---|
| 20 | Quantities of Waste Water Generated in the Wet Milling of Residues per Ton of Aluminum Recovered | 53 |
| 21 | Character of Settled Waste Water from Residue Processing | 54 |
| 22 | Pollutants Subject to Effluent Limitations | 58 |
| 23 | Magnesium Removal Practice (Demagging) Used by Secondary Aluminum Industry | 76 |
| 24 | Treatment of Effluents from Fume Scrubbing (Discharged as Noted) | 77 |
| 25 | Treatment of Effluents from Fume Scrubbing (No Discharge) | 78 |
| 26 | Effect of Neutralization and Settling on Scrubbing Waste Water Loading | 80 |
| 27 | Cost Benefit of Control and Treatment for Waste Water from Metal Cooling | 92 |
| 28 | Cost Benefit of Control and Treatment for Waste Water from Fume Scrubbing | 97 |
| 29 | Cost Benefit of Control and Treatment for Waste Water from Residue Milling | 99 |
| 30 | Conversion Factors | 131 |

# SECTION I

# CONCLUSIONS

For the purpose of establishing effluent limitations guidelines and standards of performance, the aluminum segment of the nonferrous metals manufacturing point source category was divided into three subcategories: the bauxite refining subcategory, the primary aluminum smelting subcategory, and the secondary aluminum smelting subcategory. This report deals with the secondary aluminum smelting subcategory.

Secondary aluminum smelting is a single subcategory for the purpose of establishing effluent limitations guidelines and standards of performance. The consideration of other factors such as age and size of the plant, processes employed, geographical location, wastes generated, and waste water treatment and control techniques employed support this conclusion. The similarities of the wastes produced by secondary aluminum smelting operations and the control and treatment techniques available to reduce the discharge of pollutants further substantiate the treatment of secondary aluminum smelting as a single subcategory. However, guidelines for the application of the effluent limitations and standards of performance to specific facilities do take into account the size of the secondary aluminum smelting facility and the mix of different recovery processes possible in a single plant.

Approximately 10 percent of the secondary aluminum smelting industry is currently discharging directly to navigable waters. The majority of the industry discharges effluents into municipal treatment works, usually with some treatment. It is concluded that the industry can achieve requirements set forth herein for metal cooling, fume scrubbing, and wet residue milling effluents by July 1, 1977, by the best practicable control technology currently available. Those plants not presently achieving the July 1, 1977, limitations for all three operations would require an estimated capital investment of $20 per annual metric ton and an increased operating cost of about $9.4 per annual metric ton of aluminum produced. It is estimated that to decrease the discharge of pollutants for all three operations to the July 1, 1983, level would require a capital investment of $140 per annual metric ton with an estimated operating cost of $3.7 per annual metric ton of aluminum produced.

# SECTION II

# RECOMMENDATIONS

In the secondary aluminum industry, waste water is generated principally from three operations: cooling of molten aluminum alloy, wet scrubbing of fumes during chemical magnesium removal, and the wet milling of aluminum melt residues such as dross and slag. Ingots and shot are cooled with water by direct contact with the mold and metal. Magnesium content in aluminum alloys is adjusted by the chemical removal of magnesium, using either chlorine or aluminum fluoride. Waste waters containing very large levels of suspended and dissolved solids are produced during the wet milling of residues containing aluminum.

## Best Practicable Control Technology Currently Available

### Metal Cooling Waste Water

The best practicable control technology currently available for metal cooling waste water is air cooling or continuous recycling of cooling water with periodic removal, dewatering, and disposal of sludge. The effluent limitation for metal cooling waste water, to be achieved by existing sources by July 1, 1977 through the application of the best practicable control technology currently available, is no discharge of process waste water pollutants to navigable waters.

### Fume Scrubbing Waste Water

The best practicable control technology currently available applicable to effluents from chloride fume scrubbing (magnesium removal processes using chlorine) is pH adjustment and settling. The best practicable control technology currently available applicable to effluents from fluoride fume scrubbing (magnesium removal processes using aluminum fluoride) is pH adjustment, settling, and total recycle of water.

The effluent limitations for chloride fume scrubbing waste water, to be achieved by existing sources by July 1, 1977, through the application of the best practicable control technology currently available are given in Table 1. The effluent limitation for fluoride fume scrubbing waste water, to be achieved by existing sources by July 1, 1977, by the application of the best practicable control technology currently available is no discharge of process waste water pollutants to navigable waters.

### Residue Milling Waste Water

The best practicable control technology currently available for residue milling waste water is pH adjustment with settling and

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TABLE 2. EFFLUENT LIMITATIONS FOR TREATED WASTE WATER FROM RESIDUE MILLING TO BE ACHIEVED BY JULY 1, 1977, BASED ON THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

| Effluent Characteristic | Effluent Limitations<br>Average of daily values for 30 consecutive days shall not exceed |
|---|---|
| | Metric units (kilograms per 1,000 kg of product) |
| TSS | 1.5 |
| Fluoride | .4 |
| Ammonia (as N) | .01 |
| Aluminum | 1.0 |
| Copper | .003 |
| COD | 1.0 |
| pH | Within the range of 7.5 to 9.0 |
| | English units (pounds per 1,000 lb of product) |
| TSS | 1.5 |
| Fluoride | .4 |
| Ammonia (as N) | .01 |
| Aluminum | 1.0 |
| Copper | .003 |
| COD | 1.0 |
| pH | Within the range of 7.5 to 9.0 |

the judicious application of water recycle to minimize the volume of waste water discharged.

The effluent limitations for residue milling waste water to be achieved by existing sources by July 1, 1977 through application of the best practicable control technology currently available are given in Table 2.

## Best Available Technology Economically Achievable

The best available technology economically achievable for the secondary aluminum smelting subcategory is equivalent to the following:

(a) Metal Cooling Waste Water
  (1) The use of air cooling.
  (2) The use of water cooling, so that all water is evaporated.
  (3) The total reuse and recycle of cooling water by use of settling and sludge dewatering.
(b) Fume Scrubber Waste Water
  (1) The use of aluminum fluoride for magnesium removal.
  (2) The use of one of the alternative processes such as the Alcoa process, the Derham process or the Tesiscrb process.(1)
(c) Residue Milling Waste Water
  (1) Dry milling.
  (2) A water recycle, evaporation, and salt reclamation process.

The effluent limitations for the secondary aluminum smelting subcategory, to be achieved by existing sources by July 1, 1983, by the application of the best available technology economically achievable is no discharge of process waste water pollutants to navigable waters.

## Best Available Demonstrated Control Technology

The best available demonstrated control technology, processes, operating methods or other alternatives is equivalent to the following technologies:

(a) Metal Cooling Waste Water
  (1) The use of air cooling.
  (2) The use of water cooling, so that all water is evaporated.
  (3) The total reuse and recycle of cooling water by use of settling and sludge dewatering.
(b) Fume Scrubber Waste Water
  (1) The use of chlorine for magnesium removal with wet scrubbing.
  (2) The use of aluminum fluoride for magnesium removal.

---

(1) Mention of trade names or specific products does not constitute an endorsement by the Environmental Production Agency

### TABLE 1. EFFLUENT LIMITATIONS FOR TREATED FUME SCRUBBER WASTE WATER GENERATED DURING CHLORINE DEMAGGING TO BE ACHIEVED BY JULY 1, 1977, BASED ON THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

| Effluent Characteristic | Effluent Limitations |
|---|---|
| | Average of daily values for 30 consecutive days shall not exceed |
| | Metric units (kilograms per 1,000 kg magnesium removed) |
| TSS | 175 |
| COD | 6.5 |
| pH | Within the range of 7.5 to 9.0 |
| | English units (pounds per 1,000 lb magnesium removed) |
| TSS | 175 |
| COD | 6.5 |
| pH | Within the range of 7.5 to 9.0 |

(c) Residue Milling Waste Water
  (1) Dry milling.
  (2) A water recycle, evaporation, and salt reclamation process.

The standard of performance for new sources in the secondary aluminum smelting subcategory is no discharge of process waste water pollutants to navigable waters. An exception to the standards of performance is provided for new sources using chlorine in the magnesium removal process to allow the discharge of process waste water pollutants from the magnesium removal process only. The standards of performance for such sources should be identical to the effluent limitations presented in Table 1.

# SECTION III

# INTRODUCTION

## Purpose and Authority

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act.

Section 301(b) also requires the acievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) to the Act.

Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable, including treatment techniques, process and procedure innovations, operation methods and other alternatives. The regulations contained herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for the secondary aluminum smelting subcategory of the nonferrous metals category.

## Methods Used for Development of Effluent Limitations Guidelines and Standards of Performance

The effluent limitations guidelines and standards of performance contained herein were developed in the following manner. The secondary aluminum industry, a segment of the aluminum subcategory of the nonferrous metals industry, was first categorized for

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the purpose of determining whether separate limitations and standards would be appropriate for the different subsegments. Such categorization was based on water usage, raw materials processed, products produced, manufacturing, plant age and size, and other factors.

General information was obtained on the industry and detailed information on 69 plants (81 percent) of an estimated 85 domestic secondary aluminum smelting plants. The sources and types of information consisted of the following:

- Applications to the Corp of Engineers for permits to discharge under the Refuse Act Permit Program (RAPP) were obtained for four plants. These provided data on characteristics of intake and effluent waters, water usage, raw materials and daily production.

- Information for the selection of plants for on-site visits was made through a telephone survey of 69 plants. Data were obtained on the raw materials used, products produced, type of furnaces, pretreatment of scrap, methods used for magnesium removal, degassing methods, air pollution control methods, solid waste management practice, waste water management methods and disposition, and availability of cost data for treatment operations.

- An on-site inspection of nine plants, selected from the group above, provided detailed material and water flow information. Data on waste water treatment equipment and operational costs, as well as information on process alternatives, were obtained. Analytical data for various waste streams within the plant were also compiled whenever available. Table 3 summarizes the features of these plants.

The raw waste water characteristics were identified. This included: 1) the source of the waste water, 2) the volume of the waste water, 3) the points of discharge, and 4) the waste water constituents. The constituents of the waste water, which should be subject to effluent limitations, were identified. Control and treatment technologies existing for each type of waste water produced were identified. This included both inplant and end-of-process technologies. Also, the effluent levels resulting from the application of each treatment and control technology were identified. Limitations, reliability, and problems of such technology were also identified.

The effects of the application of such technologies upon other pollution problems, including air, solid waste and noise, were also identified in order to establish nonwater environmental impacts. The energy requirements, as well as the costs of the application of such technologies, were identified.

This information, as outlined above, was evaluated to determine what levels of technology constituted the best practicable

## TABLE 3. SUMMARY OF FEATURES OF PLANTS VISITED

| Features | Plants |
|---|---|
| **Operations** | |
| Smelters | 9 |
| Refine | 6 |
| $AlF_3$ | 2 |
| $Cl_2$ | 4 |
| Residue Mills | |
| Dry | 2 |
| Wet | 2 |
| **Air Pollution Controls** | 8 |
| Demagging Fumes | 6 |
| Wet scrubber control | 5 |
| Dry control | 1 |
| Milling Dust | 2 |
| Dry | 2 |
| **Plant Capacities, thousand metric tons melted aluminum per month** | |
| 0.50 or less | 1 |
| 0.50-1.00 | 3 |
| 1.00-2.00 | 2 |
| over 2.00 | 3 |
| **Raw Materials** | |
| Scrap (solids) only | 5 |
| Residues (dross, slag, etc.) only | 2 |
| Both scrap and residues | 2 |
| **Plant Locations** | |
| Midwest | 5 |
| East | 2 |
| South | 2 |

control technology currently available, the best available technology economically achievable, and the best available demonstrated control technology, processes, and operating methods or other alternatives. In identifying such technologies, the total cost of the application of the technology in relation to the effluent reduction benefits to be achieved from such application, the processes employed, the engineering aspects of the application of control techniques proposed through process changes, the nonwater quality environmental impact and other factors were identified.

Data for identification and analyses were derived from several sources, including EPA research information, information from State water pollution control agencies, trade organizations, and the trade literature. Supplemental data were obtained by making telephone surveys and site visits to interview personnel and obtain and analyze samples of water streams at exemplary secondary aluminum smelters.

## General Description of the Secondary Aluminum Industry

The secondary aluminum subcategory is defined for the purposes of this document as that segment of the aluminum industry which recovers, processes, and remelts various grade of aluminum bearing scrap to produce metallic aluminum or an aluminum alloy as a product. Although primary aluminum producers recover captive scrap generated from their own operations, they are not included in this subcategory. The secondary smelters buy scrap in various forms on the open market as their raw material. Companies that cast or alloy remelt billets, ingots, or pigs, and whose raw materials, processes, and products differ from those of secondary aluminum smelters are not included in this subcategory of the nonferrous metals manufacturing category of sources.

The scrap raw material used by secondary smelters can be divided into two categories, solids and residues. The solids are principally metal and include borings and turnings, new clippings and forgings, old castings and sheet, and aluminum containing iron. Residues include (1) dross and skimmings from melting operations at foundries, fabricators and from the primary aluminum industry and (2) slag formed during secondary smelting operations. It is the task of the secondary aluminum industry smelters to reprocess the scrap, so that it can be used for consumer goods. In so doing, they are recycling a moderately priced metal, which otherwise would become a solid waste. Such recycling conserves both natural resources and energy since only 5 percent of the energy needed to produce virgin aluminum is required to produce an equal amount of secondary aluminum.

The scrap must undergo a presmelting process before it is converted to the various aluminum alloys. This is done primarily through selective scrap mixing and blending during melting.

Further refining is attained by chemical treatment and/or addition of alloying metals.

The types and amounts of products of the secondary aluminum industry as reported by the Bureau of Mines are listed in Table 4.

About 90 percent of metal supplied by the secondary aluminum producers goes to foundries. Of this amount, 60 percent is consumed in die castings and 25 percent as permanent mold and sand castings, and in alloy additions to zinc die castings. Most alloys sold by secondary smelters to the casting industry fall into the following categories:

(1) Aluminum-copper alloys.
(2) Aluminum-copper-silicon alloys.
(3) Aluminum-silicon alloys.
(4) Aluminum-magnesium alloys.
(5) Aluminum-magnesium-silicon alloys.

These are sold primarily as 15-pound and 30-pound ingots. Larger quantities are sold in 1000-pound sows or as hot molten alloy. Although not considered alloy production, some scrap (10 percent) is melted to produce deoxidizer for use in steel mills either in the form of shot or notched bar. Secondary aluminum smelters have been in operation since 1904, with major growth and expansion periods in the 1920's and late 1940's and 1950's. Their numbers have decreased over the last decade due to industrial consolidation and technical obsolescence.

Most of the 85 plants currently producing secondary aluminum metal are located near heavily industrialized areas, which give them proximity to a supply of scrap and to their customers (see Figure 1). There is no real need for them to be near plentiful supplies of electrical power and water, as in the case of primary aluminum smelters. Most of these plants are located in the Midwest, in or near the Chicago and Cleveland metropolitan areas and in the Los Angeles area. The east coast has plants located near the New York City - Philadelphia area. There are none in the Rocky Mountain states.

These plants produced about 14 percent of the nation's aluminum in 1970. Annual capacity is considerably above the level shown for 1970 operations since, unlike primary plants, secondary smelters do not operate around the clock and, thus, can step up production by operating extra shifts. On a company basis, the two largest secondary aluminum smelting companies supply 30 percent of the secondary aluminum produced and the next four largest companies supply another 30 percent, for a total of 60 percent production by the six largest companies.

Since most secondary smelters offer essentially the same product line, there is no competitive advantage to be realized from product offering. In addition, since the products are produced according to rigid trade specifications, product differentiation

TABLE 4. PRODUCTION OF ALUMINUM ALLOYS BY SECONDARY SMELTERS
(1970 and 1971)

| | 1970 | | 1971 | |
|---|---|---|---|---|
| | Production, metric tons | Production, short tons | Production, metric tons | Production, short tons |
| Pure aluminum (Al minimum 97.0 percent) | 64,295 | 70,873 | 77,351 | 85,265 |
| Aluminum-silicon: | | | | |
| 95/5 Al-Si, 356, etc. (maximum Cu 0.6 percent) | 15,338 | 16,907 | 16,543 | 18,236 |
| 13 percent Si, 360, etc. (maximum Cu 0.6 percent) | 42,031 | 46,331 | 39,882 | 43,962 |
| Aluminum-silicon (Cu 0.6 to 2 percent) | 5,342 | 5,889 | 4,820 | 5,313 |
| No. 12 and variations | 7,722 | 8,512 | 6,032 | 6,649 |
| Aluminum-copper (maximum Si, 1.5 percent) | 741 | 817 | 425 | 469 |
| No. 319 and variations | 45,068 | 49,679 | 42,580 | 46,882 |
| Nos. 122, 138 | 918 | 1,012 | 1,215 | 1,339 |
| AXS-679 and variations | 280,206 | 308,875 | 292,210 | 322,106 |
| Aluminum-silicon-copper-nickel | 15,888 | 17,508 | 15,187 | 16,741 |
| Deoxidizing and other destructive uses: | | | | |
| Grades 1 and 2 | 15,658 | 17,260 | 14,307 | 15,771 |
| Grades 3 and 4 | 9,377 | 10,336 | 7,542 | 8,314 |
| Aluminum-base hardeners | 4,323 | 4,765 | 3,885 | 4,282 |
| Aluminum-magnesium | 710 | 783 | 799 | 881 |
| Aluminum-zinc | 4,685 | 5,164 | 3,750 | 4,134 |
| Miscellaneous | 21,871 | 24,109 | 23,689 | 26,113 |
| Total | 534,169 | 588,820 | 550,169 | 606,457 |

Source: U.S. Bureau of Mines

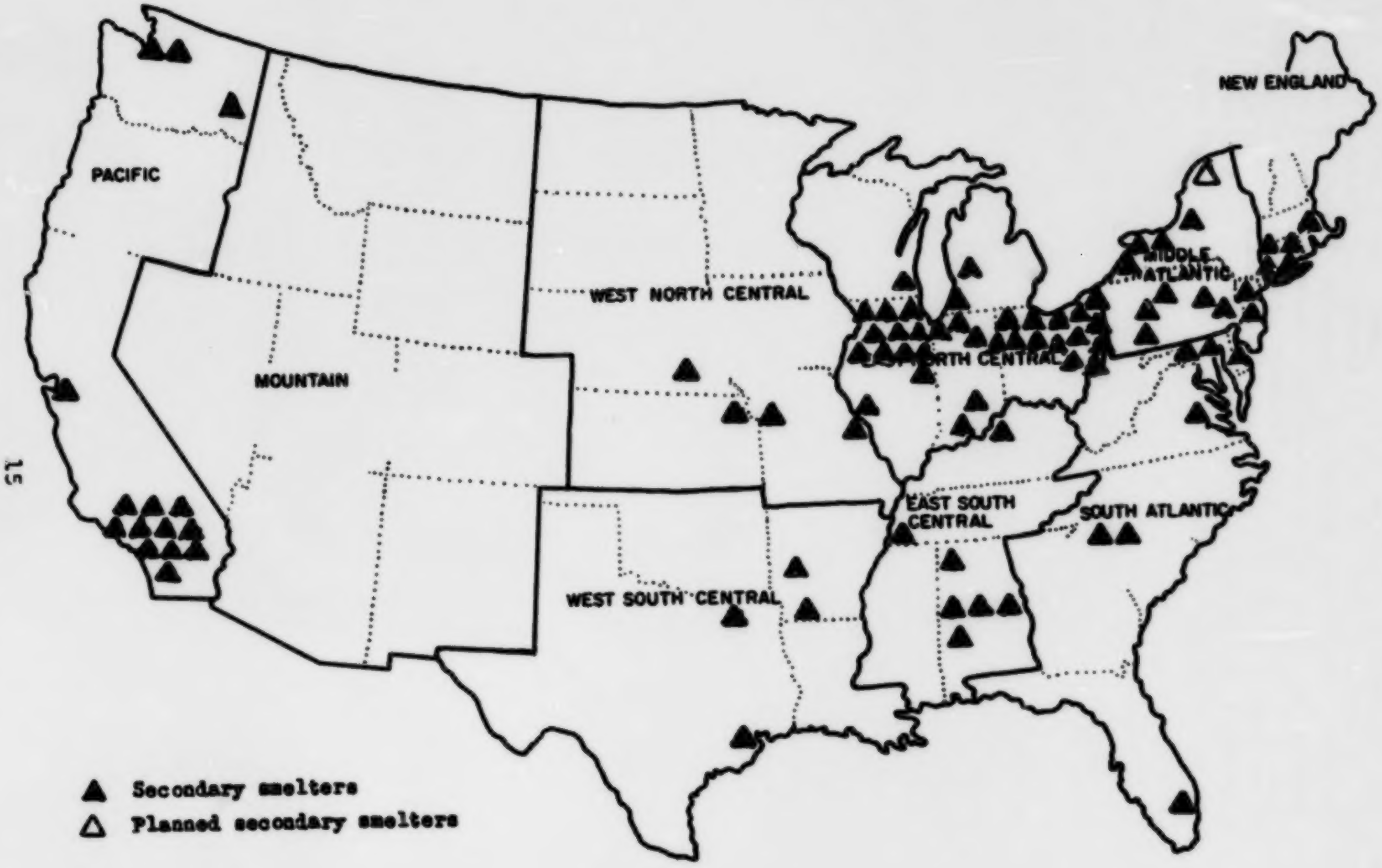
NEW ENGLAND
PACIFIC
MIDDLE ATLANTIC
WEST NORTH CENTRAL
EAST NORTH CENTRAL
MOUNTAIN
EAST SOUTH CENTRAL
SOUTH ATLANTIC
WEST SOUTH CENTRAL
▲ Secondary smelters
△ Planned secondary smelters

Figure 1. Location of secondary aluminum smelters.

is negligible and cannot be used as a factor of competition. Primary and secondary aluminum prices tend to fluctuate independently of one another, as each is basically derived from different factors. Secondary prices are usually lower. However, as primary prices go up, scrap usually becomes more expensive. Conversely, a decline in the primary price usually drives the scrap prices down, especially in times of plentiful scrap. Long-term commitments for secondary aluminum product at a fixed price can become an economic hardship in times of scrap shortages.

# SECTION IV

# INDUSTRY CATEGORIZATION

## Introduction

This section describes the scope of the secondary aluminum smelting industry. Included are technical discussions of the raw materials used, methods of production, and products produced. Rationales for possible subcategorization of the industry for the establishment of separate effluent limitations guidelines are also discussed.

## Objective of Categorization

The objective of industry categorization is to identify and examine the factors in an industry which might serve as bases for the further subdivision of the industry for the purpose of establishing effluent limitations and standards of performance.

## Definition of the Industry

The secondary aluminum industry is herein defined as that portion of SIC 3341 (Secondary Nonferrous Metals) which recovers, processes, and remelts various grades of aluminum bearing scrap to produce metallic aluminum or an aluminum alloy as a product. This does not include the casting or alloying of remelted billets, ingots, or pigs, nor those operations of the primary aluminum industry, which recycle certain categories of scrap.

## Process Description

The recovery of aluminum from various forms of aluminum scrap involves four rather distinct operations. These are:

(1) Collection, sorting, and transporting.
(2) Presmelting preparation.
(3) Charging, smelting, and refining.
(4) Pouring of the product line.

The last three operations vary somewhat throughout the industry, with resultant variations in water usage and waste water generation. Figure 2 gives a generalized flowsheet of secondary aluminum industry operations. The flowsheet includes initial collection of aluminum bearing scrap, presmelting scrap

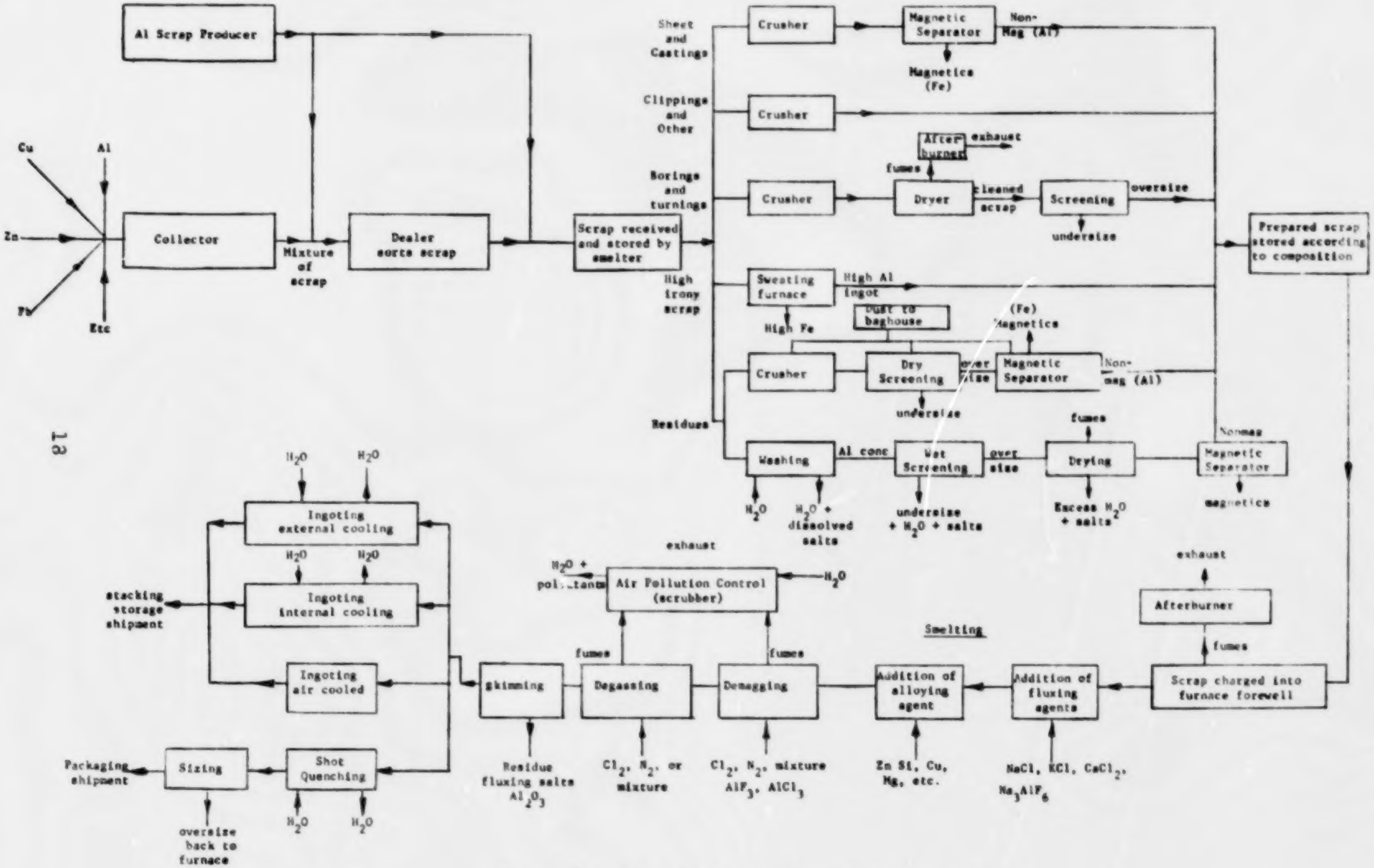
Cu
Al
Zn
Pb
Etc
Al Scrap Producer
Collector
Mixture of scrap
Dealer sorts scrap
Scrap received and stored by smelter
Sheet and Castings
Clippings and Other
Borings and turnings
High irony scrap
Residues
Crusher
Magnetic Separator
Non-Mag (Al)
Magnetics (Fe)
Crusher
Crusher
Dryer
fumes
After burner
exhaust
cleaned scrap
Screening
oversize
undersize
Sweating furnace
High Al ingot
High Fe
Dust to baghouse
Crusher
Dry Screening
undersize
over size
Magnetic Separator
(Fe) Magnetics
Non-mag (Al)
Washing
$H_2O$
$H_2O$ + dissolved salts
Al conc
Wet Screening
undersize + $H_2O$ + salts
over size
Drying
fumes
Excess $H_2O$ + salts
Nonmag
Magnetic Separator
magnetics
Prepared scrap stored according to composition
Scrap charged into furnace forewell
fumes
Afterburner
exhaust
Smelting
Addition of fluxing agents
NaCl, KCl, $CaCl_2$, $Na_3AlF_6$
Addition of alloying agent
Zn Si, Cu, Mg, etc.
Demagging
$Cl_2$, $N_2$, mixture $AlF_3$, $AlCl_3$
fumes
Degassing
$Cl_2$, $N_2$, or mixture
fumes
Air Pollution Control (scrubber)
exhaust
$H_2O$
$H_2O$ + pollutants
Skimming
Residue fluxing salts $Al_2O_3$
Ingoting external cooling
$H_2O$
$H_2O$
Ingoting internal cooling
$H_2O$
$H_2O$
Ingoting air cooled
stacking storage shipment
Shot Quenching
$H_2O$
$H_2O$
Sizing
oversize back to furnace
Packaging shipment

Figure 2. The total secondary aluminum process.

concentration and preparation, charging the scrap into the furnace for melting, refining of the melt by demagging and addition of alloying agents, and finally, the pouring of the product line. The following is a description of each operation listed.

## Collection, Sorting, and Transporting

Nearly 95 percent of the secondary smelting raw material is supplied from scrap aluminum purchased from scrap dealers and industrial plants. Classifications and chemical analyses of the scrap have been specified by the Aluminum Smelters Research Institute (ASRI) (now the Aluminum Recycling Association). Table 5 gives the ASRI classification. It should be noted that nowhere in the classification and grading of scrap is there a mention of the magnesium content in the aluminum scrap, only the levels of copper, silicon, and zinc (and iron). The reason for this practice is that magnesium can be removed from the alloy by chemical action (demagging), while the others, because of their lower reactivity, cannot be removed by chemical action. Adjustment in concentration of elements other than magnesium is done by dilution or blending with pure aluminum. Thus, secondary aluminum smelters, because of the interrelationship of scrap availability, varying chemical reactivity of the elements in the scrap, and the cost of pure aluminum for dilution, tend to purchase materials which offer an optimum trade-off between demagging and dilution.

A portion of the secondary scrap and various other metals supply is gathered by metal collectors or junk dealers. These collectors haul loads of mixed metals to scrap dealers, who segregate or sort the scrap into various metals. More often, however, the dealer will have accounts with various government agencies, aircraft firms, railroads, or other aluminum scrap producers and acquire the metal directly.

The scrap used by the secondary smelters can be divided into five main groupings:

(1) New clippings, forgings, and other solids.
(2) Borings and turnings.
(3) Residues.
(4) Old castings and sheet.
(5) High iron (sweated pig).

New clippings, forgings, and other solids originate from the aircraft industry, fabricators, industry manufacturing plants, and government manufacturing plants. Borings and turnings are derived mainly from the machining of castings, rods, and forgings by the aircraft and automobile industries. Residues (dross, skimmings, and slag) originate from melting operations at primary reduction plants, secondary smelting operations, casting plants, and other foundries. Old castings and sheet may come from many sources, as automobile parts, household items, and dismantled

# TABLE 5. A.S.R.I. ALUMINUM SCRAP CLASSIFICATIONS

## CLASSIFICATIONS:

1. NEW PURE ALUMINUM CLIPPINGS: Shall consist of new, clean, unalloyed sheet clippings and/or aluminum sheet cuttings, free from oil, grease, foil and any other foreign substance and from punchings less than one-half inch in size.

2. NEW PURE ALUMINUM WIRE AND CABLE: Shall consist of new, clean, unalloyed aluminum wire or cable free from hair wire, wire screen, copper, iron, insulation and any other foreign substance.

3. OLD PURE ALUMINUM WIRE AND CABLE: Shall consist of old, unalloyed aluminum wire or cable containing not over 1 per cent free oxide or dirt and free from hair wire, wire screen, copper, iron, insulation and any other foreign substance.

4. SEGREGATED NEW ALUMINUM ALLOY CLIPPINGS. Shall consist of new, clean, uncoated aluminum clippings of one specified aluminum alloy only, free from hair wire, wire screen, foil, can stock, stainless steel, iron, dirt, oil, grease and any other foreign substance, and from punchings less than one-half inch in size.

5. MIXED NEW ALUMINUM ALLOY CLIPPINGS. Shall consist of new, clean, uncoated aluminum clippings of two or more alloys, none of which shall be alloys containing zinc in excess of .25% (such as 7,000 series), tin in excess of .30%, and/or magnesium in excess of 2.80%. To be free from hair wire, wire screen, foil, can stock, stainless steel, iron, dirt, oil, grease and/or any other foreign substance. Shall not contain punchings less than one half inch in size.

6. MIXED LOW COPPER ALUMINUM ALLOY CLIPPINGS. Shall consist of new, clean, uncoated aluminum clippings of two or more alloys, none of which shall exceed a maximum of .40% copper, .25% zinc, .30% tin, and 2.80% magnesium; and shall be free from tin-containing alloys, hair wire, wire screen, stainless steel, iron, dirt, oil, grease and/or any other foreign substance, and shall be free from punchings less than one-half inch in size.

7. SEGREGATED OLD ALUMINUM ALLOY SHEET: Shall consist of clean, uncoated, old aluminum sheet of one specified alloy only, free from wrecked airplane sheet, hair wire, wire screen, foil, stainless steel, iron, dirt, oil, grease and any other foreign substance.

8. MIXED OLD ALLOY SHEET: Shall consist of clean, uncoated, old alloy sheet aluminum of two or more alloys not to contain wrecked airplane sheet and to be free from hair wire, wire screen, oil cans, foil, food or beverage containers, stainless steel, iron, dirt, oil, grease and all other foreign substances.

9. SCRAP SHEET AND SHEET UTENSIL ALUMINUM: Shall consist of clean, uncoated manufactured sheet aluminum, free from stainless steel, iron, dirt, or any other foreign substances and to be free from hub caps, radiator shells, airplane sheet, foil, food or beverage containers, pie plates, oil cans, bottle caps, and lawn furniture.

10. SEGREGATED NEW ALUMINUM CASTINGS, FORGINGS, AND EXTRUSIONS. Shall consist of new, clean, uncoated aluminum castings, forgings and extrusions of one specified alloy only and to be free from sawings, stainless steel, zinc, iron, dirt, oil, grease and any other foreign substances.

11. MIXED NEW ALUMINUM FORGINGS AND EXTRUSIONS. Shall consist of clean, new, uncoated aluminum forgings and extrusions of two or more alloys, none of which shall be alloys containing zinc in excess of .25% (such as 7,000 series), tin .30% and/or magnesium in excess of 2.80%. Shall also be free from sawings, stainless steel, zinc, iron, dirt, oil, grease and any other foreign substance.

12. MIXED NEW ALUMINUM CASTINGS: Shall consist of clean, new, uncoated aluminum castings of two or more alloys, none of which shall exceed 3% zinc, .50% tin, and/or magnesium in excess of 2.80%. Shall be free of sawings, stainless steel, iron, dirt, oil, grease, and any other foreign substances.

13. ALUMINUM AUTO CASTINGS: Shall consist of all clean automobile aluminum castings of sufficient size to be readily identified and to be free from iron, dirt, brass, babbitt bushings, brass bushings and any other foreign materials. Oil and grease not to exceed 2%.

14. ALUMINUM AIRPLANE CASTINGS: Shall consist of clean aluminum castings from airplanes and to be free from iron, dirt, brass, babbitt bushings, brass bushings and any other foreign materials. Oil and grease not to exceed 2%.

15. MIXED ALUMINUM CASTINGS: Shall consist of all clean aluminum castings which may or may not contain auto and airplane castings, but no ingots, and to be free from iron, dirt, brass, babbitt and any other foreign materials. Oil and grease not to exceed 2%.

16. ALUMINUM PISTONS:
    (a) CLEAN ALUMINUM PISTONS. Shall consist of clean aluminum pistons to be free from struts, bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%.

    (b) ALUMINUM PISTONS WITH STRUTS: Shall consist of clean whole aluminum pistons with struts to be free from bushings, shafts, iron rings and any other foreign materials. Oil and grease not to exceed 2%.

    (c) IRONY ALUMINUM PISTONS: Should be sold on recovery basis, or by special arrangements with purchaser.

17. WRECKED AIRPLANE SHEET AND/OR BREAKAGE ALUMINUM: Should be sold on recovery basis, or by special arrangements with purchaser.

18. NEW ALUMINUM FOIL: Shall consist of clean, new, pure, uncoated, unalloyed aluminum foil, free from etched radar foil, paper, dirt, lead, stainless steel, iron, tin, solder, plastic or any other foreign materials. Should not be packed in hydraulic briquettes.

19. OLD ALUMINUM FOIL: Shall consist of clean, old, uncoated, pure, unalloyed aluminum foil, free from etched and radar foil, paper, dirt, lead, stainless steel, iron, tin, solder, plastic or any other foreign materials. Should not be packed in hydraulic briquettes.

20. ALL OTHER ALUMINUM BASE FOILS INCLUDING ETCHED FOIL, RADAR FOIL AND CHAFF. Should be sold by special arrangements with purchaser.

21. SEGREGATED ALUMINUM BORINGS AND TURNINGS: Shall consist of clean, uncorroded aluminum borings and turnings of one specified alloy only and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or any free magnesium or stainless steel or containing highly flammable cutting compounds, will not constitute good delivery.

22. MIXED ALUMINUM BORINGS AND TURNINGS: Shall consist of clean, uncorroded aluminum borings and turnings of two or more alloys and subject to deductions for fines in excess of 3% through a 20 mesh screen and dirt, free iron, oil, moisture and all other foreign materials. Material containing iron in excess of 10% and/or any free magnesium or stainless steel or containing highly flammable cutting compounds, will not constitute good delivery. To avoid dispute should be sold on basis of definite maximum zinc, tin and magnesium content.

23. SWEATED ALUMINUM: Shall consist of aluminum scrap which has been sweated or melted into a form or shape such as an ingot, pig or slab for convenience in shipping; to be free from corrosion, drosses or any foreign materials. Should be sold subject to sample or analysis.

24. ALUMINUM GRINDINGS: Should be sold on recovery basis, or by special arrangements with purchaser.

25. ALUMINUM DROSSES, SPATTERS, SPILLINGS, SKIMMINGS AND SWEEPINGS: Should be sold on recovery basis, or by special arrangements with purchaser.

26. ALUMINUM HAIR WIRE: Should be sold by special arrangements with purchaser.

27. ALUMINUM WIRE SCREEN: Should be sold by special arrangements with purchaser.

28. COATED ALUMINUM (PAINTED OR PLASTIC COATED, ETC.): Should be sold by special arrangements with purchaser. Siding, awnings, and venetian blinds should each be packaged separately.

29. CONTAINERS OF ALL TYPES (OIL, FOOD, BEVERAGE, AEROSOL): Should be sold by special arrangements with the purchaser, and should each be packaged separately.

30. ITEMS NOT COVERED SPECIFICALLY BY ABOVE CLASSIFICATIONS: Any new item which might appear and which is not covered specifically by above classifications should be discussed and sold by special arrangements with the purchaser.

airplanes. Miscellaneous high iron scrap requires special handling in sweating furnaces. Table 6 gives the consumption of scrap by type of secondary smelter for the years 1970 and 1971.

The dealer sorts the collected aluminum scrap into groups of similar composition and physical shape. Sheet, extruded material, and castings are often baled into 3 x 6 ft bundles. Some dealers briquette borings and turnings for shipment. High iron scrap may be treated by the dealer to concentrate the aluminum, or may be shipped directly to the smelter. The high iron scrap is heated to above 760°C (1400°F) in a sloping hearth or grate furnace, which is direct-fired by natural gas (a "sweating furnace"). The aluminum melts, flows away from the residual iron, and is cast into pigs (sweated pigs) or sows. In many cases the various types of scrap are shipped loosely in large bins.

Many secondary aluminum smelters have accounts with scrap producers and receive segregated shipments directly without dealer handling. This does not mean that they take over the function of a dealer, since their sources of scrap define the chemical composition of the scrap they receive.

The collection, sorting, and transporting of aluminum scrap are elements of the secondary aluminum industry relatively unimportant to this study, because such functions are not part of the secondary smelter operation and water was not used in these operations. Conceivably a dealer operating a sweat furnace to recover high iron aluminum may use a wet scrubber to reduce fumes, although no such case is known. Such operations typically employ an afterburner to reduce air pollution.

## Presmelting Preparation

The presmelting preparation of scrap varies in accordance with the type of scrap being handled. Some smelters do considerable preparation to upgrade and segregate scrap. Those with more limited facilities bypass some of the preparation steps and rely upon the furnace to burn up combustible contaminants. Here, contaminating metallics taken up into the melt can be diluted with relatively pure scrap, while free iron can be raked from the furnace bottom. New clippings and forgings are largely uncontaminated and require little presmelter treatment other than sorting, either manually or mechanically to remove obvious non-aluminum material. This scrap is stored in tote boxes and charged directly into the furnace forewell.

Borings and turnings are often heavily contaminated with cutting oils. In spite of this fact, some plants charge this material directly into the forewell. Most, however, pretreat this material. Typically, this material is received in long, intertwined pieces and must be crushed in hammer mills or ring crushers. The crushed material is then fed into gas or oil-fired rotary dryers to remove cutting oils, grease, and moisture.

### TABLE 6. CONSUMPTION OF NEW AND OLD SCRAP IN THE UNITED STATES IN 1970 AND 1971[a] BY SECONDARY SMELTERS

| | 1970 Consumption | | 1971 Consumption | |
|---|---|---|---|---|
| | metric tons | short tons | metric tons | short tons |
| New scrap: | | | | |
| Solids | 98,769 | (108,874) | 110,617 | (21,934) |
| Segregated low copper (Cu max. 0.4%) | 98,769 | (108,874) | 110,617 | (21,934) |
| Segregated high copper | 12,154 | (13,397) | 13,250 | (14,606) |
| Mixed low copper | 58,904 | (64,930) | 66,221 | (72,996) |
| High zinc (7,000 series type) | 8,278 | (9,125) | 5,673 | (6,253) |
| Mixed clips | 46,276 | (51,010) | 41,101 | (45,306) |
| Borings and turnings | 145,150 | (160,000)[b] | 146,964 | (162,000)[b] |
| Foil, dross, skimmings, and other | 100,886 | (111,208) | 86,415 | (95,256) |
| Old Scrap (solids) | 113,985 | (125,647) | 107,413 | (118,402) |
| Sweated pig (purchased for own use) | 42,976 | (47,373) | 52,747 | (58,144) |

(a) After U.S. Bureau of Mines Mineral Yearbook.

(b) Estimated, figure withheld from Minerals Yearbook to avoid disclosure of individual company confidential data.

After drying, the material is screened for removal of fines, with the oversize passing through a magnetic separator to remove tramp iron. The undersize material would contribute excessive oxides if charged into the furnace and is often sold as pyrotechnics.

Of the 69 secondary smelters surveyed in the study, 23 process residues (dross, slags, skimmings, etc.). In addition to 10 to 30 percent metallic aluminum, these residues contain oxides, carbides, fluxing salts, and other contaminants. To recover the metallic aluminum, it is necessary to liberate it from the contaminants. This can be done in either wet or dry processes.

In the dry circuit, the material is crushed, in attrition or ball mills, screened to remove the fines, and passed through a magnetic separator to remove any iron. Large amounts of dust are created in this circuit and provide a source of air pollution. Normally, the dust emissions are controlled by passage through baghouses. Wet dust collection is done at two of the plants surveyed processing dross. The dry residue waste, after aluminum removal, is piled on the plant site in the open. Markets for the high alumina material exist and are being developed.

Six of the 23 plants processing residues use wet techniques. Generally, the raw material is first fed into a long rotating drum. Water is passed through the drum to wash the feed, carry away the fluxing salts and chemicals, and liberate the aluminum. The washed material is then screened, dried, and passed through a magnetic separator. The nonmagnetics are then ready for the smelter. Fine particulates, dissolved salts, and screening undersize are all sources of water pollution.

In some plants, sheets and castings may be charged directly into the reverberatory forewell, as received. In most cases, this category of scrap goes to crushers, which reduce it to small dimensions. The crushed material is passed along vibrating screens and magnetic separators to remove pulverized nonmetallics and free iron, respectively.

Aluminum scrap containing considerable amounts of iron generally is pretreated to eliminate the iron. This may consist of crushing followed by magnetic separation or, more commonly, removal in a sweating furnace. The operation of the sweating furnace has been previously described. Fumes from the furnace generally are passed through an afterburner before being emitted to the atmosphere.

In summary, of the various presmelter treatments employed, only the wet processing of drosses and slags appears to provide a source of water pollutants.

## Smelting

Generally, the smelting of aluminum scrap with reverberatory furnaces consists of seven operations or tasks. These are charging scrap into the furnace, addition of fluxing agents, addition of alloying agents, mixing, removal of magnesium (demagging), degassing, and skimming. Any given smelter may not necessarily incorporate all seven steps, as demagging or addition of alloying agents in the case of deoxidant producers, and may not follow the above order. There is some variability in the secondary aluminum industry as to precise techniques used in each step. These variations and their contribution to waste and environmental effects are discussed.

Charging. Scrap may be charged continuously into the furnace, with simultaneous pouring, or may be loaded in batches. Deoxidant producers, not particularly concerned about the exact composition of the melt, often use continuous loading. Specification alloy producers, however, need to maintain a critical compositional range through selective melt additions and, thus, are confined to batch loadings. Often residual melt ("heel") is left in the reverberatory to facilite melting of the new charge. This results in a shortened heating cycle.

Forklifts or front-end loaders are used to charge the furnace through the forewell with the various types of scrap. Depending on the capacity of the furnace (9100 to 82,000 kg), it takes 4 to 75 hours to fully charge a furnace, with the average being 24 hours. Each complete smelting cycle is called a heat. The time required for each heat is dependent on the materials charged, size and design of furnace, heat input, fluxing procedures, and alloying practices.

The addition of scrap into the forewell is accompanied by varying amounts of fuming and smoke generation, depending on the cleanliness of the scrap as it contacts the molten metal. The forewell area is sometimes hooded and vented into an afterburner for fume and smoke cleanup. The absence of moisture during charging is necessary for safety reasons. No water is used during this operation.

Fluxing. The addition of a covering flux to the molten aluminum melt forms a barrier for gas absorption and oxidation of the metal. The flux also reacts with nonmetallics, residues from burned coating, and dirt in the scrap, collects such impurities and allows physical separation from the molten aluminum. The exact composition flux cover used varies from smelter to smelter, but is generally some combination containing one or more of the following: sodium chloride, potassium chloride, calcium chloride, calcium fluoride, aluminum fluoride, and cryolite. A common flux mixture is 47.5 percent NaCl, 47.5 percent KCl, and 5 percent cryolite. At the melting point of aluminum, the fluxes usually range from a tacky semisolid to a liquid depending on the composition of the mixture and the technique used to remove it from the melt.

The amount of flux used depends primarily on the material charged. Scrap containing a relatively large surface area, such as borings and turnings, creates large amounts of oxides and requires proportionally larger amounts of flux. The flux generally is added along with the aluminum scrap in amounts from less than 10 percent to 33 percent by weight of the material charged.

Alloying. Alloying agents, normally added to the aluminum melt, include copper, silicon, manganese, magnesium, and zinc. Usually these are added after the furnace has been charged with aluminum scrap and analyzed for its composition. The amounts of additions required to bring it up to specifications are then added. These additions are usually scrap, which is high in the concentration of the desired element or, as in the case of silicon, in the pure state. These are added to the forewell and stirred into the melt with an inert gas ($N_2$). The addition of the alloying agents and the stirring produces no solid waste and only minor amounts of fumes and dust, that are removed from the working area by the hoods over the forewell.

Mixing. Mixing of the metal to insure uniform composition and to agitate the solvent fluxes into the melt is generally accomplished by injecting nitrogen gas. Aside from homogenizing the melt, the mixing step is beneficial in bringing to the surface dissolved gases, such as hydrogen, and intermixed solids. Once on the surface the impurities combine with the fluxing agent and can be skimmed off.

Mixing is performed nearly continuously in the reverberatory furnace. Mixing often does double duty and serves as a degassing operation. In such cases a mixture of nitrogen and chlorine (90 percent-10 percent) is often used. The mixing operation employs no water and produces no solid wastes. Only when the mixture of nitrogen and chlorine is used are fumes generated.

Magnesium Removal (Demagging). Scrap aluminum, received by the secondary smelters, averages about 0.3 to 0.5 percent magnesium, while the product line of alloys produced averages about 0.1 percent. Therefore, after the furnace is fully charged and the melt brought up to the desired chemical specification, it is usually necessary to remove the excess magnesium. This is done with chlorine or chlorinating agents, such as anhydrous aluminum chloride or chlorinated organics, or with aluminum fluoride. Magnesium chloride or magnesium fluoride is formed and collected in the fluxing agents on top of the molten melt. As the magnesium level is depleted, chlorine will consume aluminum and the aluminum chloride or aluminum fluoride present in excess volatilizes into the surrounding air and is a source of air pollution.

Magnesium is the only metal removable from the alloy in this manner. Other metal alloy levels must be adjusted by the addition of either more aluminum dilution or more of the metal.

Chlorination, the method preferred by the industry for demagging, is performed at temperatures between 760 and 816°C (1400 and 1500°F). As a rule of thumb, the reaction requires 3.5 kg of chlorine per kg of magnesium removed. Elemental chlorine gas is fed under pressure through tubes or lances to the bottom of the melt. As it bubbles through the melt it reacts with magnesium and aluminum to form chlorides, which float to the melt surface where they combine with the fluxing agents and are skimmed off. Because magnesium is above aluminum in the electromotive series, aluminum chloride will be reduced by any available magnesium in the melt. At the beginning of the demagging cycle, the principal reaction product is magnesium chloride. As magnesium is removed and there is less available for reaction with chlorine, the reaction of chlorine with aluminum becomes more significant, the reduction of the aluminum chloride by magnesium becomes less likely, and the production of aluminum chloride, a volatile compound, becomes significant. The aluminum chloride escapes and considerable fuming results from the chlorination, making ventilation and air pollution equipment necessary. Control of fumes is frequently done by wet scrubbing and, thus, is a source of water contamination.

Aluminum fluoride as a demagging agent reacts with the magnesium to form magnesium fluoride, which in turn combines with the flux on top of the melt, where it is skimmed off. In practice, about 4.3 kg of aluminum fluoride are required per kg of magnesium removed. The air contaminants exist as gaseous fluorides or as fluoride dusts and are a source of air pollution. The fluorides are controlled by either dry or wet methods. When done dry, a solid waste problem exists. When done wet, both a water pollution problem (which must be treated) and solid waste problem exist.

Some operators in the secondary industry are little concerned with the magnesium content of their product, as the deoxidant manufacturers, and they make no attempt at removing it. They, thus, do not contend with the magnitude of fumes that the demaggers do and as a result, do not require extensive air pollution control equipment and related water usage.

Skimming. The contaminated semisolid fluxing agent, known as slag (sometimes as dross), is removed from the surface of the melt in the forewell, usually with a perforated ladle or similar device, that permits molten metal to drain back into the forewell. This is done just before tapping the reverberatory furnace to pour ingots. The slag is placed in pans to cool or in an internally water-cooled dross cooler.

Once cooled, the slag is either stored until shipped to a residue processor, reprocessed by the company, or is dumped. If stored in the open, it is a source of ground and runoff water contamination, because of contained soluble salts (NaCl, KCl, $MgCl_2$). During dross cooling, thermiting generates fumes and is a source of air pollution. The thermiting, as well as reactions in the smelting, produce nitrides and carbides of aluminum which, upon reacting with water or water vapor in the air, release hydrocarbons and ammonia to the atmosphere. The ammonia also may become a component of water pollution.

**Pouring and Cooling.** After the furnace has been completely charged, the specification composition reached by blending and demagging, and the melt degassed and skimmed, the molten metal is cooled to around 732°C (1350°F) for pouring. Pouring practices employed and the related water usage by any given smelter will, of course, be dependent on the company's product-line. The product-lines of the secondary aluminum smelters have been grouped into six categories. These are specification alloy ingots, billets, hot metal, notched bar, shot, and hardeners.

**Specification Alloy Ingots.** The most important product of the secondary aluminum industry is specification alloy ingots to be used by foundries for casting. Most smelters concentrate on a few of the basic alloys. Normally automatic casting methods are used to fill the ingot molds. The molds are, generally, the 15 or 30-pound size.

Cooling often is accomplished with a water spray, that contacts both the molds and hot metal as they move along a conveyor track above a casting pit. Cooling also is performed by a few companies by passing water through passages in the mold, in which case water does not contact the hot aluminum metal. In some cases, the molds are cooled by passing the hot ingots through a cooling tunnel, blown with a water mist-air mixture, thus generating no waste water. Eleven of 69 plants canvassed are currently air cooling their ingots. The water used for cooling may be sent to a cooling tower and recirculated, or it may be used only once and discharged. Recirculated water often builds up sludge in both the cooling tower and cooling pit. This necessitates sludge removal at regular intervals and is accompanied by a discharge of system water.

**Billets.** Secondary aluminum for use in the extrusion industry is cast into 454 kg (1000 pound) billet logs The long cylindrical billet molds are 7 to 10 inches in diameter and about 10 feet long. The molds are arranged in circular arrays. A riffle above each array splits the molten metal into fractions, filling each simultaneously.

Water lines inside the molds cool the billets. The billet logs are then removed and cut into shorter two foot sections. The cooling water is generally cooled and reused, as is the case for ingot cooling.

**Hot Metal.** In some cases, hot metal is tapped from the reverberatory furnace into preheated portable crucibles. The crucibles are sealed, placed on a flat bed truck and transported directly to the customers for use. Presently, crucibles with up to 6,810 kg (15,000 lb) capacity are used.

**Notched Bar.** Notched bar is used as a deoxidant by the iron and steel industry and is normally cast in various 0.9 to 2.3 kg (2 to 5 lb) shapes. Four grades are produced, each grade having a different aluminum content. Notched bar molds are cooled, either with water sprays, internal water lines, or with air. The water used may or may not be cooled and recirculated.

Shot. Shot is also used as a deoxidant and comes in various compositional grades. Shot is produced by pouring the molten metal onto a vibrating feeder, where perforated openings in the bottom allow the molten metal to drop through into a water bath below. The droplets solidify in the water, are dried, sized, and packed for shipment. The oversize shot is recharged into the furnace. Quenching water is usually sent to a cooling tower and recirculated. Sludge build-up occurs and must be removed regularly on an annual or semi-annual basis.

Hardeners. Hardeners are sometimes produced by specially equipped secondary smelters. The hardeners are alloys of high-purity aluminum with titanium, boron, and chromium. They are produced in small capacity 908 kg (2000 lb) induction furnaces, rather than reverberatory furnaces.

In summary, water usage in the pouring phase of secondary aluminum smelting is for mold cooling or shot quenching. In some cases, water contacts hot aluminum and, in other cases, it contacts only the mold cooling lines. Some smelters cool and recirculate the water, while others use fresh water continuously. The recirculated water is periodically discharged, normally at six-month intervals.

## Industry Categorization

A survey was made of the secondary aluminum industry, which covered such factors for subcategorization as raw materials used, product line, processes employed, water usage, plant age, and plant capacity. Sixty-nine plants, out of an estimated total of 85, were surveyed. Nine plants were visited by interviewing teams. The results of the survey indicate that the secondary industry should be considered as a single category. Rationale for this judgment is given below.

### Results of Industry Inventory

A portion of the information obtained in the industry survey of 69 plants is tabulated in Tables 7 through 10. Respectively, these tables contain data on plants generating no waste water (seven each), plants generating only cooling waste water (28 each), plants generating waste water from fume scrubbing and/or cooling operations (26 each), and plants generating waste water from the wet processing of residues and/or fume scrubbing and cooling (eight each). Categorization of smelters on the basis of waste water generation is not possible, because a given smelting plant may have any combination of the three waste streams. A

TABLE 7. SECONDARY ALUMINUM SMELTERS A. THOSE CLAIMING NO PROCESS WATER USE

| Company | Plant Age, Yrs | Employees | Raw Materials | Products | Process or Demag Type | Air Pollution Control | Process Water Usage | | | | Wastewater Treatment | | Discharge To |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | None | Cooling Water | Air Scrubber Water | Dross Proc. | Current | Future | |
| A-1 | - | - | Solids, 18-19x$10^6$ lb/yr | Casting Alloy<br>Ingot<br>15x$10^6$ lb/yr | $AlF_3$ | No | + | | | | NA* | | NA |
| A-2 | - | - | Dross<br>Own Slag<br>6.0-6.5x$10^6$ lb/mo | Spec Alloy & Remelted scrap<br>Ingot<br>1.6x$10^5$ lb/mo | None | Dry | + | | | | NA | | NA |
| A-3 | - | - | Solids<br>0.75-1.25x$10^6$ lb/mo | Spec Alloy<br>Ingot<br>0.6x$10^6$ lb/mo | $Cl_2/AlF_3$ | No | + | | | | NA | | NA |
| A-4 | - | - | Dross & Slag | - | - | - | + | | | | NA | | NA |
| A-5 | - | - | Solids<br>Own Slag<br>1.5x$10^6$ lb/mo | Spec Alloy<br>Ingot<br>1.0x$10^6$ lb/mo | $AlF_3$ | Dry | + | | | | NA | | NA |
| A-6 | 35 | 15-30 | Solids, 20%<br>0.20x$10^6$ lb/mo<br>Cu, brass, 80% | Foundr Alloy<br>0.18x$10^6$ lb/mo | Dilution | No | + | | | | NA | | NA |
| A-7 | - | - | Solids<br>Own Slag | Remelt | Melt Only | No | + | | | | NA | | NA |

* Not Applicable.

TABLE 8. SECONDARY ALUMINUM SMELTERS B. SMELTERS USING WATER FOR INGOT COOLING ONLY

| Company | Plant Age, Yrs | Employees | Raw Materials | Products | Process or Demag Type | Air Pollution Control | Process Water Usage |  |  |  | Wastewater Treatment |  | Discharge to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | None | Cooling Water | Air Scrubber Water | Dross Proc. | Current | Future |  |
| B-1 | - | - | Solids, new<br>0.15-0.20x<br>$10^6$/mo | Deox<br>Shot<br>Bar | None | Dry |  | + |  |  | Recirc.<br>& Cool |  | Zero |
| B-2 | - | - | Irony Scrap | Deox<br>Shot | None | None |  | + |  |  | Recirc.<br>1000 gal |  | Ground/6 mo. |
| B-3 | - | - | Solids<br>0.6x$10^6$lb/mo | Spec Alloy<br>Ingot | $AlF_3$ | None |  | + |  |  | None |  | Sanitary Sewer |
| B-4 | - | - | Solids<br>7x$10^6$lb/mo | Billet Alloy<br>6.0 x $10^6$lb/mo | None | None |  | + |  |  | Recirc.<br>$10^6$gal |  | Sanitary Sewer |
| B-5 | - | - | Solids<br>Dross<br>12x$10^6$lb/mo | Spec Alloy<br>Ingot<br>10x$10^6$lb/mo | $AlF_3$ | Dry |  | + |  |  | None | Recirc. | Sanitary Sewer<br>City Approved |
| B-6 | - | - | Solids<br>3.3x$10^6$lb/mo | Spec Alloy<br>Ingot<br>3.0x$10^6$lb/mo | $Cl_2/AlF_3$ | Dry |  | + |  |  | Recirc.<br>Cooling |  | Zero |
| B-7 | - | - | Solids<br>7x$10^6$lb/mo | Deox<br>Shot<br>Bar<br>6x$10^6$lb/mo | None | None |  | + |  |  | Recirc.<br>Colling |  | Flood Sewers/<br>6 mo. |
| B-8 | - | - | Solids<br>Own Slag<br>2.9x$10^6$lb/mo | Spec Alloy<br>Ingot<br>2.5x$10^6$lb/mo | $Cl_2$ | None<br>(Bag House)<br>Soon |  | + |  |  | Recirc.<br>Cooling |  | Own Wet Well |
| B-9 | - | - | Solids | Spec Alloy<br>Ingot |  |  |  | + |  |  | None |  | Sanitary Sewer |
| B-10 | - | - | Solids<br>2.3x$10^6$lb/mo | Die Cast<br>Alloy<br>Billets | None? | None |  | + |  |  | None |  | Pond |
| B-11 | 45 | - | Solids<br>Dross<br>Slag<br>20x$10^6$lb/mo | Deox<br>Shot<br>Bar<br>1.5-2.0<br>x$10^6$lb/mo | None | Dry |  | + |  |  | None | Recirc. | River<br>80 F Winter<br>110 F Summer |
| B-12 | 40 | 95 | Solids<br>Cu<br>Zn | Ingot | $AlF_3$ | None |  | + |  |  | ? | - | ? |

TABLE 8. (Continued)

| Company | Plant Age, Yrs | Employees | Raw Materials | Products | Process or Demag Type | Air Pollution Control | Process Water Usage |  |  |  | Wastewater Treatment |  | Discharge to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | None | Cooling Water | Air Scrubber Water | Dross Proc. | Current | Future |  |
| B-13 | - | - | Solids<br>$20 \times 10^6$ lb/yr | Deox<br>Shot<br>Bar<br>Shapes | None | None |  | + |  |  | None | Recirc. | Sanitary Sewer |
| B-14 | 3 | 40 | Solids<br>"Remelts"<br>$1.0 \times 10^6$ lb/mo | Diecast Alloy<br>Deox<br>Bar<br>$0.6 \times 10^6$ lb/mo | $AlF_3$ | None |  | + |  |  | Recirc. | - | ? |
| B-15 | - | - | Solids<br>$0.7 \times 10^6$ lb/mo | Spec Alloy<br>Ingot | $AlF_3$ | Dry |  | + | ? |  | Recirc.<br>Cool | - | Zero |
| B-16 | - | - | Solids<br>$1 \times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>? | $Cl_2$ | Dry |  | + |  |  | None | - | Sanitary Sewer |
| B-17 | - | - | Solids<br>$1 \times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>$0.85 \times 10^6$ lb/mo | $AlF_3$ | Dry |  | + |  |  | Recirc.<br>Cool |  | Zero |
| B-18 | - | - | Solids<br>$4.5-5 \times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>$4.0 \times 10^6$ lb/mo | $AlF_3$ | Dry |  | + |  |  | None | Recirc.<br>Cool | Sanitary Sewer |
| B-19 | - | - | Solids<br>0.25-0.3<br>$\times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>$0.25 \times 10^6$ lb/mo | None | Dry |  | + |  |  | None |  | Dry Well |
| B-20 | - | - | Solids<br>$0.40 \times 10^6$ lb/mo | Deox<br>Shot<br>Bar<br>$0.4 \times 10^6$ lb/mo | None | Dry |  | + |  |  | Recirc.<br>Cooling |  | Zero |
| B-21 | - | - | Solids<br>$2 \times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>$1.7 \times 10^6$ lb/mo | $Cl_2$ | None |  | + |  |  | None | - | Sanitary Sewer |
| B-22 | - | - | Solids<br>$3.0 \times 10^6$ lb/mo | Spec Alloy<br>Ingot<br>$2.8 \times 10^6$ lb/mo | $AlF_3$ | None |  | + |  |  | Recirc. | - | ? |

TABLE 8. (Continued)

| Company | Plant Age,Yrs. | Employees | Raw Materials | Products | Process or Demag Type | Air Pollution Control | Process Water Usage: None | Process Water Usage: Cooling Water | Process Water Usage: Air Scrubber Water | Process Water Usage: Dross Proc. | Wastewater Treatment: Current | Wastewater Treatment: Future | Discharge to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-23 | - | - | Solids<br>Dross<br>Own Slag<br>1.0x10$^6$lb/mo | Spec Alloy Ingot,<br>1x10$^6$lb/mo | $K_3AlF_6$ | Dry |  | + |  |  | None | - | Sanitary Sewer |
| B-24 | - | - | Solids<br>4-4.5x10$^6$lb/mo | "6000" spec Alloy Ingot<br>5.5-6x10$^6$lb/mo | None | None |  | + |  |  | Recirc. Cooling | - | ? |
| B-25 | 16 | 37 | Solids<br>0.65x10$^6$lb/mo<br>0.25x10$^6$lb/mo remelted | Die Cast Alloy<br>0.25x10$^6$lb/mo | None | None |  | + |  |  | Recirc. Cooling |  | Zero |
| B-27 | 20 | 4 | Solids,<br>0.4x10$^6$lb/mo | Die Cast Ingot<br>0.4x10$^6$lb/mo |  |  |  | + |  |  | None |  | Soil Surface |
| B-28 | 97 | 50-75 | Solids,<br>2.0x10$^6$lb/mo | Spec Alloy Ingot<br>1.3x10$^6$lb/mo<br>Deox<br>Shot<br>Bar<br>0.8x10$^6$/mo | $AlF_3$ | Dry |  | + |  |  | Recirc. Cooling<br>Sludge/ 6 mo |  | Sanitary Sewer |
| B-29 | - | - | Solids<br>0.75x10$^6$lb/mo | Deox<br>Shot<br>Bar<br>0.6-0.7x10$^6$ lb/mo | None | None |  | + |  |  | Recirc. Cooling |  | Zero |

TABLE 9. SECONDARY ALUMINUM SMELTERS C. WATER USED FOR SCRUBBING AND/OR COOLING

| Company | Plant Age, yrs | Employees | Raw Materials | Products | Demag Type | Air Pollution Control | Process water Usage | | | Wastewater Treatment | | Discharge to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cooling Water | Air Scrubber Water | Dross Processing | Cooling | Scrubber | |
| C-1 | -- | 50 | Solids<br>1.7x10$^6$ lb/mo.<br>Residues<br>1.3x10$^6$ lb/mo. | Spec alloy ingot<br>1.4-1.5x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | Recirc + cool desludge/6 mo. | pH control<br>Recycle<br>Discharge weekly 1500-2000 gal | Both to sanitary sewer |
| C-2 | -- | -- | Solids<br>6.0x10$^6$ lb/mo. | Spec alloy ingot<br>5.5x10$^6$ lb/mo. | $AlF_3$ | Wet<br>Venturi | + | + | | Grease trap | pH control<br>Total recycle | Cooling to sanitary sewer |
| C-3 | -- | -- | Solids<br>Residues<br>5.6x10$^6$ lb/mo. | Spec alloy ingot<br>3.5x10$^6$ lb/mo. | $AlF_3$ | Wet | + | + | | Grease trap | pH control<br>Total recycle | Cooling to sanitary sewer |
| C-4 | -- | -- | Solids<br>Own slags | Spec alloy ingot | $Cl_2$ | Temporary<br>Wet | + | + | | None | None | Lagoon; dry<br>Control planned |
| C-5 | -- | -- | Solids<br>1-1.25x10$^6$/mo. | Spec alloy ingot<br>1.2x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None | Cooled, pH control, Settling | Both to sanitary sewer |
| C-6 | -- | -- | Solids<br>1-1.2x10$^6$ lb/mo. | 380 alloy ingot<br>1x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None, 25 gpm, 4 hr/day | None, 25 gpm, 4 hr/day | Ditch; liming planned |
| C-7 | -- | -- | Solids<br>>4x10$^6$ lb/mo. | Spec alloy ingot<br>>4x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None | pH control<br>Solids removal | Storm sewer<br>Creek |
| C-8 | -- | 60-65 | Solids | Spec alloy ingot | $Cl_2$+$AlF_3$ | Wet | + | + | | Partly recycle<br>Cool | None | Pond |
| C-9 | -- | -- | Solids<br>3.6x10$^6$ lb/mo. | Spec alloy ingot<br>3.2x10$^6$ lb/mo. | $Cl_2$ | Dry/wet | + | + | | Recirc., cooling, cont. | pH control | Sanitary sewer |
| C-10 | 34 | 22 | Solids<br>1.2-1.5x10$^6$ lb. lb/mo. | Die cast ingot<br>1.2x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None | Recirc. with cont. pH control, settling solids, periodic discharge to lagoon | Cooling water to sanitary sewer, scrub solids to lagoon/3 wks. |
| C-11 | -- | -- | Solids<br>0.4x10$^6$ lb/mo.<br>Al+ Cu | Hardeners<br>0.5x10$^6$ lb/mo. | None | Wet | + | + | | None | ? | Septic tank |
| C-12 | -- | -- | Solids<br>2.5x10$^6$ lb/mo. | Ingot<br><2.5x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None | Settling ponds | River<br>Plan neutralization |
| C-13 | 14 | 100 | Solids<br>5x10$^6$ lb/mo. | Billets + sows<br>"6000" (remelt)<br>4.5x10$^6$ lb/mo. | None<br>(Remelt) | Wet<br>(Smoke) | + | + | | Recirculated | Skimming of oils and graphite | Lagoon |
| C-14 | -- | -- | Solids<br>2.5x10$^6$ lb/mo. | Spec alloy ingot<br>2x10$^6$ lb/mo. | $Cl_2$ | Wet<br>Dry planned | + | + | | Vaporized | pH control,<br>Yearly solids removal to land fill in drums | Sanitary sewer |
| C-15 | 20 | 85 | Solids<br>>2.5x10$^6$ lb/mo. | Ingot<br>2.5x10$^6$ lb/mo. | $Cl_2$ | Wet | + | + | | None | pH control<br>Solids to land fill; pond planned for solids | Sanitary sewer |

TABLE 9. (Continued)

| Company | Plant Age, yrs | Employees | Raw Materials | Products | Demag Type | Air Pollution Control | Process Water Usage: Cooling Water | Process Water Usage: Air Scrubber Water | Process Water Usage: Dross Processing | Wastewater Treatment: Cooling | Wastewater Treatment: Scrubber | Discharge to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-16 | -- | -- | Solids<br>$2.7 \times 10^6$ lb/mo. | Spec alloy ingot<br>$2.5 \times 10^6$ lb/mo. | $Cl_2$ | Wet<br>Dry planned | + | + |  | None | pH control and settling | Sanitary sewer<br>$0.5 \times 10^6$ gal/mo. |
| C-17 | -- | -- | Solids<br>$>0.5 \times 10^6$ lb/mo. | Spec Alloy ingot<br>(high Mg)<br>$<0.5 \times 10^6$ lb/mo. | $Cl_2$ | Wet | + | + |  | Recycled<br>Cooled<br>Cont. | pH control<br>Recycle cont.<br>Settling<br>Discharge/mo.<br>2000 gal | Creek |
| C-18 | -- | -- | Solids<br>$8 \times 10^6$ lb/mo. | Spec alloy<br>$6.5 \times 10^6$ lb/mo.<br>30% ingot<br>70% liquid | $Cl_2$ | Wet | + | + |  | Vaporized | pH control<br>Alkaline | Sanitary sewer |
| C-19 | -- | -- | Solids<br>$3.5 \times 10^6$ lb/mo.<br>Dross<br>Own slag | Spec alloy ingot<br>2.75 lb | $Cl_2$ | Wet | + | + |  | Recir.<br>Cooled | pH control<br>Alkaline | Discharged to ground |
| C-20 | -- | -- | Solids<br>$4\text{-}5 \times 10^6$ lb/mo.<br>Dross and own slag, $2.5 \times 10^6$ lb/mo. as metal | Spec alloy<br>$6\text{-}7 \times 10^6$ lb/mo.<br>10% ingot<br>90% molten | $Cl_2$ | Wet | + | + |  | None<br>5000 gph<br>12 hr/day | None<br>6600 gph | Sanitary sewer |
| C-21 | -- | -- | Solids<br>$2.6 \times 10^5$ lb/mo.<br>Dross and own slag, 1.4 lb/mo. metal | Spec alloy<br>$4 \times 10^6$ lb/mo.<br>10% ingot<br>90% molten | $Cl_2$ | Wet | + | + |  | None<br>5000 gph | None<br>3300 gph | Sanitary sewer |
| C-22 | -- | -- | Solids<br>$4.3 \times 10^6$ lb/mo. | Spec alloy ingot<br>$4 \times 10^6$ lb/mo. | $Cl_2$ | Wet | + | + |  | None<br>5000 gph | None<br>1000 gph | Impermeable lagoon |
| C-23 | -- | -- | Solids<br>$3.0 \times 10^6$ lb/mo.<br>Dross and own slag, $0.3 \times 10^6$ lb/mo. metal | Spec alloy ingot<br>$3 \times 10^6$ lb/mo. | $Cl_2$ | Wet | + | + |  | None<br>5000 gph | None<br>3000 gph | Sanitary sewer |
| C-24 | -- | -- | Solids<br>$2.2 \times 10^6$ lb/mo.<br>metal | Spec alloy ingot<br>$2 \times 10^6$ lb/mo. | $Cl_2$ | Wet | + | + |  | None<br>5000 gph | None<br>3300 gph | Sanitary sewer |
| C-25 | 15 | 100 | Solids<br>$1.5 \times 10^6$ lb/mo. | Spec alloy ingot<br>Deox shot<br>$1.2 \times 10^6$ lb/mo. | $Cl_2$ | Wet<br>Dry | + | + |  | None | pH control and settling | River |
| C-26 | 15 | 250-[illegible]35 | Solids<br>$11\text{-}12 \times 10^6$ lb/mo.<br>Dross and own slag, $7 \times 10^6$ lb/mo. | Spec alloy ingot<br>Molten<br>Deox shot<br>$8.6 \times 10^6$ lb/mo. | $Cl_2$ | Wet | + | + |  | None | pH control<br>Settling<br>Partially recirc. | Evaporation pond |

TABLE 10. SECONDARY ALUMINUM SMELTERS D. WATER USED FOR DROSS PROCESSING, SCRUBBING AND/OR COOLING

| Company | Plant Age, yrs | Employees | Raw Materials | Products | Demag Type | Air Pollution Control | Process Water Usage |  |  | Wastewater Treatment |  |  | Discharged to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | Cooling | Air Scrubber | Dross Proc. | Cooling | Scrubber | Dross Proc. |  |
| D-1 | -- | -- | Dross<br>Own slag | Alloy ingot<br>$Al_2O_3$ hot topping | None | Dry and wet | None | None | + | -- | -- | Recirc. discharge/6 months<br>Bag house Planned | Evaporation pond |
| D-2 | -- | -- | Dross<br>Slags<br>3.0-4.5 x $10^6$ lb/mo. | Alloy sows<br>1.2 x $10^6$ lb/mo. | None | Wet and dry | None | + | +<br>Wet milling | -- | Venturi with recirc. & sludge removal/8 hr lime pH control | Solids removal | Sludge to pond 1000 g/8 hrs<br>Dissolved salts Pond |
| D-3 | -- | -- | Dross<br>1-2 x $10^6$ lb/mo. | Alloy sows<br>0.75 x $10^6$ lb/mo. | None | Wet<br>Dry planned | None | None | +<br>Wet milling | -- | -- | Settling Floc. agent ph control ponds | River |
| D-4 | 21 | 25-30 | Dross<br>Own slag<br>3.75 x $10^6$ lb/mo. | Alloy pig<br>0.5 x $10^6$ lb/mo.<br>$Al_2O_3$ hot topping<br>Related products | None | None<br>Dry being installed | None | None | +<br>Wet milling | -- | -- | Settling Floc. agent ponds sludge recirc. | River |
| D-5 | -- | -- | Solids<br>Dross<br>Own slags<br>2 x $10^6$ lb/mo. | Spec alloy ingot<br>1.75 x $10^6$ lb/mo. | $Cl_2$ | Wet | + | +<br>80 gpm 2 hr/day | +<br>60 gpm 6 hr/day | None | pH control | Settling pond | Cooling to river<br>Scrub to sewer<br>Dross wash to pond |
| D-6 | -- | -- | Dross<br>Slags<br>8 x $10^6$ lb/mo.<br>Solids<br>2-2.5 x $10^6$ lb/mo. | Spec alloy ingot<br>RSI<br>3.5 x $10^6$ lb/mo. | $Cl_2$ | Dry | + | + | +<br>Product washing | None | None<br>pH control | Ponds | Cooling to sewer<br>Scrubber and wash to ponds |
| D-8 | -- | -- | Dross (10%)<br>Slag<br>Solids<br>3.75 x $10^6$ lb/mo. | Spec alloy ingot<br>3 x $10^6$ lb/mo. | $Cl_2$ | Wet | + | + | + | None | pH control settling ponds | Settling ponds | Ponds |
| D-9 | 30 | 250 | Dross<br>2.5 x $10^6$ lb/mo. Al<br>Solids<br>3.5-4.0 x $10^6$ lb/mo. | Spec alloy ingot 90%<br>Molten 10%<br>5.7 x $10^6$ lb/mo. | $Cl_2$ | Wet | + | + | + | None | pH control Alkaline Settling ponds | Settling ponds | Sanitary sewer |

more useful approach for the purpose of developing effluent limitations guidelines is to deal with the waste water streams themselves. Three distinct streams may be characterized: (1) cooling waste water, (2) fume-scrubbing waste water, and (3) wet-residue milling waste water. Each stream has an associated unit waste loading of pollutants per pound of product produced or scrap processed. Each may also be associated with an appropriate effluent limitations guideline. For example, the guidelines would require a smelter generating only cooling waste water to maintain waste loadings under the established level for that category. A smelter generating cooling, scrubber, and residue milling waste waters would be required not to exceed its waste loadings for each respective category of waste water under each of the established levels.

## Factors Considered for Categorization

Consideration was given to a number of other factors for possible use in subcategorization of the secondary aluminum industry. Factors taken into account include raw material processed, product line produced, processes employed, plant age, plant size, and air pollution control techniques. Upon application, each of these factors leads to unmanageable ambiguities in subcategorization, as described in the following paragraphs.

Raw Materials. The principle groupings of raw materials for the secondary aluminum industry are (1) new clippings and forgings, (2) old casting and sheet, (3) borings and turnings, (4) remelted ingot and sweated pig, and (5) residues. With the possible exception of residues, these raw materials provide no firm basis for subcategorizing the secondary industry. The first four groupings are, to the first approximation, handled by nearly all smelters at various times (the exception being a few plants using only residues). The first four groupings will be referred to collectively as solids and the fifth grouping as residues.

Out of 69 smelters interviewed by telephone or plant visit, 46 use only solid scrap, 9 use both solid scrap and residues, and four use only residues. Although the wet processing of residues can lead to water effluents different from those of a nonresidue smelter, subcategorization based on residues is complicated by those smelters handling both residues and solid scrap and that some smelters, using both forms of raw material, dry process the residue and have no water effluent from it.

Products. The main product line of secondary smelters is specification alloys (ingots or sows) and/or deoxidant (notched bar, shapes, or shot). These products are common to the industry and support the identification of a single category.

Processes. The main processes in secondary aluminum recovery of scrap consist of (1) scrap preparation, (2) charging scrap into reverberatory forewell, (3) smelting, (4) refining, and (5) casting. Scrap preparation procedures are common to the industry, as are charging and smelting procedures, and support the establishment of a single category.

A variation exists in refining, as some smelters use chlorine as a demagging agent, while others use $AlF_3$. Deoxidant producers generally have no need to refine or demag their melt. Significant to waste water treatment and effluent limitations may be that the use of chlorine or $AlF_3$ will generate unique waste water effluents when the smelter fumes are wet scrubbed. Of the 69 smelters interviewed, 46 refine their melts. Of these, 28 use only $Cl_2$, 14 use only $AlF_3$, and four use both $AlF_3$ and $Cl_2$. The presence, absence, or method of waste water treatment at these smelters is independent of the demagging process used. Thus, the response required for the achievement of performance implied by any effluent limitations guideline would be likewise independent of current process operation.

The waste products formed during magnesium removal with chlorine differ from those formed when aluminum trifluoride is used. Volatile anhydrous metal chlorides are formed when chlorine is used for demagging at 760°C (1400°F). When aluminum trifluoride is used, metal fluorides are formed, which have relatively low volatilities at 760°C. The anhydrous metal chlorides are very soluble in water; whereas, metal fluorides are sparingly soluble in water. This difference could be related to categorization. Both react with water by hydrolysis to yield acidic wet scrubber solutions, which are amenable to treatment by pH adjustment and settling to reduce pollutant concentrations. The similarity in scrubber water treatment suggests a single industrial category, regardless of the chemical system used for magnesium removal. However, the lower volatility of the fluorides places reduced load on the scrubber system for a fixed amount of magnesium removed from the melt. Low solubility of the scrubbed salts (after pH adjustment) sets the waste water generated from fluoride scrubbing apart from waste water generated from chloride fume scrubbing.

The last process step in secondary aluminum recovery, casting, is common to the industry, and supports the establishment of a single category for the industry.

Most (19 of 23) residue processing operations are associated with solids processing operations, wherein practices of water interchange and mixed waste treatment have been identified. Similarly, the wet and dry variations of residue processing are variously associated with or are independent of solids processing. This complex pattern of process distribution further supports the above described approach to deriving regulations. In addition, residues from secondary smelters (slags) containing high levels of soluble salts (NaCl and KCl) are processed along with the residues (dross) containing low levels of salt. Soluble and insoluble wastes from each material are similar and are suited to the same type of treatment to reduce suspended solids. In both cases, the soluble portions are untreatable, except by total evaporation of the water. Therefore, establishment of a single industrial category is still supported.

Plant Age. From interviews with various secondary smelters, there appears no consistent connection between plant age and waste water character or treatment. Many of the older plants have updated treatment facilities, while others have not.

Plant Size. Plant size is directly related to the number of furnaces employed (usually 2 to 8). The number of furnaces is, however, unrelated to waste water character or treatment.

# SECTION V

## WASTE CHARACTERIZATION

### Introduction

Specific processes in the secondary aluminum industry generate characteristic waste water streams. In this section of the document, each waste water stream is discussed as to source, quantities, and characteristics, in terms of the process operation from which it arises.

### Specific Water Uses

The secondary aluminum industry generates waste waters in the following processes:

(1) Ingot cooling and shot quenching.
(2) Scrubbing of furnace fumes during demagging.
(3) Wet milling of residues or residue fractions.

### Waste Water From Metal Cooling

Sources. Molten metal in the furnace is generally either cast into ingot or sow molds or is quenched into shot. In cases where cooling waste water is generated, the ingot molds are attached to conveyors which carry the molds and their molten charge of aluminum over a cooling pit. Here water is sprayed onto the mold to solidify the aluminum and allow its ejection from the mold. In some cases the molds contain internal cooling lines through which water is passed. In these cases the water does not contact the molten metal. Sows are generally air cooled and have little associated water use.

The production of shot involves water usage for the rapid quenching of molten metal. Here the molten metal is poured into a vibrating porous container which allows the metal to pass through as droplets. The drops of molten metal fall into a water bath below and are quickly solidified. From the water bath, they are conveyed to a dry screening operation.

In a survey conducted on 69 secondary smelters, 57 were found to be using water for cooling purposes. It was learned from the survey that the cooling water used has five possible dispositions. The water may be (1) completely vaporized, (2) discharged to municipal sewage or navigable waters after one passage through the cooling circuit, (3) recycled for some period and discharged (6-month intervals), (4) continuously recycled with no discharge, and (5) discharged to holding ponds after one passage through the cooling circuit. The disposition of the cooling waters by the 57 smelters is as given in Table 11.

Quantities. Data on the quantity of water used for metal cooling in the secondary industry is very sparse and of questionable quality. Only a small number of plants had even approximate water quantity figures. Data gathered was converted to liters used per metric tons of metal cooled and is given in Table 12. As is evident, the values vary widely. It is not certain whether these great differences are real or whether they are due to grossly inaccurate estimates of water flow. Each of the plants listed in Table 12 is discharging the cooling waste water after one passage through the circuit. Plants recycling their cooling water had very limited information on the amount of water used per ton of product cooled.

Characteristics. Of the 69 secondary smelters surveyed, one plant, B-11, had analytical data on cooling waste water (for a Corps of Engineers' permit). To better characterize the nature of cooling waste water, sampling teams were sent to plants C-7 and D-6 for water samples. Samples obtained were analyzed for appropriate constituents and related to pollutant loadings per metric ton of alloy cooled. Data on plants C-7, D-6, and B-11 are given in Tables 13, 14, and 15. The tables show that pollutant levels in the cooling waste waters, with the exception of oil and grease, are relatively low.

A great deal of variability in waste loading is noted in some of the parameters. For instance, total dissolved solid loadings range between 0 and 1.34 kg per metric ton of alloy cooled.

Recirculation of cooling water produces sludge and accumulates oil and grease contamination. The sources of sludge include collection of airborne solids from ambient air during spray cooling of the water, buildup of hydrated alumina from chemical reaction with the molten aluminum and debris and dust from the plant floor. Flux salt buildup ($NaCl$) occurs in recirculated water used for shot cooling. Water used once and discharged will contain oil and grease contaminants. There are operations in which the rate of water flow for cooling is controlled to assure total evaporation.

## Waste Water From Fume Scrubbing Sources

Aluminum scrap normally charged into the furnace contains a higher percentage of magnesium than is desired for the alloy produced. It is, therefore, necessary to remove a portion of this element from the melt. Magnesium removal, or "demagging," is normally accomplished by either passing chlorine through the melt (chlorination), with the formation of magnesium chloride ($MgCl_2$), or by mixing aluminum fluoride ($AlF_3$) with the melt, with the removal of magnesium as $MgF_2$. Heavy fuming results from the demagging of a melt, and these fumes are often controlled by passing them through a wet scrubbing system. Water used in the

## TABLE 11. COOLING WATER DISPOSAL PRACTICES

| Disposition of Cooling Water | | Number |
|---|---|---|
| Completely vaporized | | 3 |
| Discharged directly after use | | 26 |
| Discharged after some recirculation | | 7 |
| Recycled continuously | | 15 |
| Discharged to holding pond | | 6 |
| | Total | 57 |

## TABLE 12. COOLING WATER USAGE BY SECONDARY SMELTERS

| | Water Use liters/metric ton of metal cooled (gallons/short ton) | |
|---|---|---|
| Plant | Ingot Cooling | Shot Quenching |
| C-7 | 680 (160) | |
| C-26 | 250 (60) | |
| C-20 | 2,300 (550) | 60,000 (14,400) |
| D-6 | 570 (140) | |
| B-11 | 11,500 (2,760) | |

TABLE 13. CHARACTER OF COOLING WASTE WATER
(Plant C-7)

| Parameter | Intake Water | | Effluent Concentrations in Samples, (mg/1) | | | | Net Loadings in Waste Water[(b)] (gram/mton) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Conc. (mg/1) | Loading[(a)] gram/mton | 6 | 15 | 16 | Average | Average | Min | Max |
| Alkalinity | 8 | 5.43 | 6 | 16 | -- | 7.3 | -- | -- | 5.37 |
| COD | 4 | 2.71 | 1000 | 365 | 2252 | 1206 | 815 | 245 | 1525 |
| Total solids | 86 | 58.4 | 234 | 188 | 3222 | 1215 | 766 | 69.2 | 2128 |
| Total dissolved solids | 73 | 49.5 | 78 | 118 | 548 | 248 | 119 | 3.4 | 322 |
| Total suspended solids | 6 | 4.07 | 102 | 64 | 2620 | 929 | 626 | 39.4 | 1774 |
| Sulfate | 6 | 4.07 | 10 | 15 | 21 | 15.3 | 6.3 | 2.7 | 10.2 |
| Chloride | 6 | 4.07 | 16 | 12 | 401 | 143 | 93.0 | 4.07 | 268 |
| Cyanide | <0.02 | <0.013 | 0.05 | <0.02 | <0.02 | 0.03 | 0.006 | 0 | 0.020 |
| Fluoride | 1.04 | 0.706 | 0.84 | 1.36 | 0.16 | 0.78 | -- | -- | 0.217 |
| Aluminum | 0.01 | 0.007 | 0.01 | 0.08 | 32.0 | 10.7 | 7.26 | 0 | 21.7 |
| Calcium | 2.38 | 1.62 | 2.60 | 3.10 | 1.07 | 2.26 | -- | -- | 0.489 |
| Copper | 0.037 | 0.025 | 0.037 | 0.037 | 0.325 | 0.133 | 0.065 | 0 | 0.195 |
| Magnesium | 1.95 | 1.32 | 1.07 | 1.07 | 1.37 | 1.17 | -- | -- | -- |
| Nickel | <0.02 | <0.014 | 0.043 | <0.02 | <0.02 | 0.03 | 0.007 | 0 | 0.016 |
| Sodium | 3.19 | 2.16 | 2.81 | 2.91 | 5.06 | 3.59 | 0.271 | -- | 1.27 |
| Zinc | 0.031 | 0.021 | 0.231 | 0.038 | 1.555 | 0.61 | 0.393 | 0.005 | 1.03 |
| Cadmium | <0.009 | <0.006 | 0.009 | <0.009 | 0.027 | 0.015 | 0.004 | 0 | 0.012 |
| Lead | <0.026 | <0.018 | 0.026 | 0.052 | 1.147 | 0.46 | 0.261 | 0 | 0.76 |
| Manganese | <0.010 | <0.006 | 0.042 | 0.042 | 0.229 | 0.10 | 0.061 | 0.022 | 0.149 |
| Chlorine residue | <0.02 | <0.014 | 0.02 | 0.02 | <0.02 | 0.02 | 0 | 0 | 0 |
| Oils and grease | 6.3 | 4.28 | 255.6 | 64.3 | 5180 | 1833 | 1240 | 39.4 | 3511 |
| Phenols (ppb) | 30 | 0.020 | 35 | 3 | 260 | 99.3 | 0.043 | -- | 0.156 |
| pH | 6.7 | | 3.4 | 7 | 6.1 | 5.5 | 5.5 | 3.4 | 7 |

(a) $\frac{\text{(conc., mg/1) (water used, 1/day)}}{\text{(metric tons poured, mT/day)}} \times 10^{-3}$ gram/mg = loading in grams/metric ton of alloy, where water used is 39,700 1/day (average) and metric tons poured is 58.5 mT/day (average)

(b) minus intake load.

## TABLE 14. CHARACTER OF COOLING WASTE WATER
(Plant D-6)

| Parameter | Intake Water[a] Conc. (mg/1) | Effluent Concentrations in Samples, (mg/1) | | | | | | | Net Loadings in Waste Water(c) (gram/mton) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | Avg. | Avg. | Min. | Max. |
| Alkalinity | 292 | 271 | -- | 278 | 355 | 131 | 149 | 237 | --- | --- | 36 |
| COD | 3.8 | 228 | 134 | 456 | 160 | 365 | 122 | 244 | 138 | 68 | 261 |
| Total solids | 203 | 711 | 788 | 1663 | 654 | 2422 | 639 | 1146 | 545 | 252 | 1282 |
| Total dissolved solids | 184 | 661 | 665 | 1412 | 567 | 2146 | 475 | 989 | 465 | 168 | 1134 |
| Total suspended solids | 19 | 50 | 123 | 251 | 78 | 276 | 164 | 157 | 80 | 18 | 60 |
| Sulfate | 12 | 20 | 25 | 28 | 23 | 28 | 19 | 24 | 7 | 4 | 9 |
| Chloride | 8.2 | 223 | 160 | 622 | 108 | 582 | 165 | 310 | 174 | 58 | 355 |
| Cyanide | ND[b] | .004 | .003 | ND | ND | ND | ND | .004 | .002 | --- | .002 |
| Fluoride | 2.5 | 2.4 | 2.3 | 2.0 | 2.0 | 2.6 | 2.6 | 2.3 | --- | --- | .06 |
| Aluminum | 2.7 | 0.3 | 6.3 | 2.2 | 0.3 | 0.5 | 0.3 | 1.7 | --- | --- | 2.1 |
| Calcium | 14.0 | 6.0 | 6.2 | 41.5 | 5.1 | 41.7 | 9.6 | 18.4 | 0.33 | --- | 16.0 |
| Copper | ND | ND | ND | 0.026 | ND | ND | ND | 0.026 | 0.015 | --- | --- |
| Magnesium | 1.26 | 2.83 | 2.68 | 7.50 | 2.68 | 6.00 | 2.63 | 4.05 | 1.61 | 0.79 | 3.60 |
| Nickel | 0.08 | ND | ND | 0.47 | 0.15 | ND | 0.15 | 0.26 | 0.10 | 0.04 | 0.22 |
| Sodium | 5.55 | 450 | 375 | 1450 | 325 | 1700 | 100 | 733 | 420 | 54 | 979 |
| Zinc | 0.002 | 0.011 | 0.005 | 0.017 | 0.012 | 0.022 | 0.013 | 0.013 | 0.006 | 0.002 | 0.012 |
| Cadmium | ND | ND | ND | ND | ND | ND | 0.01 | 0.01 | 0.006 | --- | --- |
| Lead | 0.10 | ND | 0.10 | 0.10 | ND | ND | 0.10 | 0.10 | --- | --- | --- |
| Manganese | 0.01 | 0.30 | 0.23 | 0.70 | 0.15 | 0.30 | 0.12 | 0.30 | 0.17 | 0.06 | 0.40 |
| Oils and grease | 4.5 | 57.5 | 60.5 | 36.4 | 24.5 | 891 | 484 | 259 | 147 | 12 | 512 |
| Phenols | ND | ND | ND | ND | ND | ND | ND | ND | --- | --- | --- |
| pH | 5.4 | 7.5 | 7.3 | 4.9 | 5.3 | 6.0 | 7.6 | 6.4 | --- | --- | --- |

(a) Average of 4 samples.

(b) ND = Not detected.

(c) $\frac{\text{[Conc. effluent-conc. intake (mg/1)] x (water used 1/day)}}{\text{Amount of metal cooled, mtons/day}} \times 10^{-3}$ gram/mg = loading (gram/m ton)

(d) Water flow 30g pm for 260 min average time/day

(e) 51 mtons/day(56 tons/day)

## TABLE 15. CHARACTER OF COOLING WASTE WATER
(Plant B-11[a])

| | Intake Water Municipal mg/l | Discharge mg/l[a] Avg. | Net loading in Waste-water gram/mton[b] Average |
|---|---|---|---|
| Alkalinity | 95 | 95 | --- |
| COD | NA[c] | 15 | 172 |
| Total solids | 192 | 198 | 69 |
| Total dissolved solids | 190 | 180 | --- |
| Total suspended solids | 2 | 18 | 182 |
| Ammonia | 0.01 | 1.1 | 12.5 |
| Nitrate | 0.06 | 0.07 | 0.11 |
| Chloride | 25 | 29 | 46 |
| Fluoride | 1.01 | 0.9 | --- |
| Aluminum, µg | -- | 0.7 | 0.008 |
| Oil and grease, lb/day | -- | 5 (?)<br>(7.5 mg/l) | 86 |
| pH | 4.5-6.5 | 4.5-6.5 | --- |
| Temperature, F | NA | 97-112 | --- |
| Temperature, C | | 36-44 | --- |

Volume: 80,000 gal/day = 302,800 l/day. Product: 25-33 tons/day = 23-30 mton/day.

(a) Corp of Engineers data.

(b) $\frac{\text{[Conc effluent - conc intake (mg/l)] x liters/day}}{\text{Avg. amount of metal cooled, mtons/day}} \times 10^{-3}$ gram/mg = loading, gram/mton

(c) NA = Not applicable.

scrubbing gains resulting pollutants and is the source of a waste water stream.

Waste water from $AlF_3$ demagging gas scrubbers can normally be recirculated because of the relative insolubility of fluorides (which can be settled out). Waste water from the scrubbing of chlorine demagging fumes, however, can be recycled only to a very limited degree. This is because the chloride salts are highly soluble and would soon build up to make water unusable. Thus, the discharge of this effluent is the source of waste water from fume scrubbing. Table 16 gives data on present smelter practices in regard to scrubbing waste water. Of 69 plants surveyed, 46 are demagging their melts. No demagging waste water discharges are reported from those plants using $AlF_3$. All plants using chlorine are discharging demagging scrubber waste water, whether to navigable waters, public sewage, or holding ponds.

Quantities. Very few smelters in the secondary industry have reliable water-use data for their fume scrubbing systems. In one plant, D-6, water usage measured by the project sampling team was one-third the usage estimated by company personnel. In general, data given out by the plants should be used with caution.

Data on the quantities of water used in scrubbing, which were most consistent in terms of their content, are given in Table 17. Water usage is given in liters per kilogram of magnesium removed during the demagging operation. Basing the water use on magnesium removal provides a common unit for all smelters. The values in Table 17 are fairly consistent, with the average water use being 150 liters per kilogram of magnesium removed.

Characteristics. The character of the raw waste water generated during the scrubbing of chlorination fumes is given in Table 18. No similarly detailed data on this waste water was available in the secondary aluminum industry. The data on plants C-7 and D-6 were obtained by sending project water sampling teams to the plant sites for representative samples. The waste water samples were then analyzed for appropriate constituents.

At plant C-7, fumes were scrubbed in a tower, followed by neutralization and settling of the raw waste water in separate unit operations. This arrangement permitted sampling the acidic effluent from the scrubber before it was treated and is one example of raw fume scrubber waste water collected by a tower. At plant D-6, the fumes were trapped under a proprietary bell-shaped device in contact with the molten metal and were scrubbed with water. This arrangement also permitted sampling of raw untreated waste water from a different method of fume scrubbing. Simultaneous scrubbing and pH adjustment is considered a treatment and the treated waste water is characterized in Section VII.

Table 18 gives both effluent concentrations (milligrams per liter) and loadings (grams of pollutants per kilogram of magnesium removed). For almost every parameter listed, the

## TABLE 16. FUME SCRUBBING WASTE WATER -- GENERATION AND DISPOSAL PRACTICES

| Practice | Number of Plants | | |
|---|---|---|---|
| • Use $AlF_3$ for demagging | | | 14 |
| No air pollution control | | 5 | |
| Dry air pollution control | | 7 | |
| Wet air pollution control | | 2 | |
| - Water recycled continuously | 2 | | |
| • Use $Cl_2$ for demagging | | | 28 |
| No air pollution control | | 3 | |
| Dry air pollution control | | 1 | |
| Wet air pollution control | | 24 | |
| Wastewater discharged: | | | |
| - with no recycling | 12 | | |
| - with some recycling | 6 | | |
| - no discharge-continuously recycled | 0 | | |
| - to evaporation pond | 7 | | |
| - with neutralization | 17 | | |
| - with solids removal | 12 | | |
| • Use both $AlF_3$ and $Cl_2$ for demagging | | | 4 |
| No air pollution control | | 1 | |
| Dry air pollution control | | 1 | |
| Wet air pollution control | | 2 | |
| Wastewater discharged: | | | |
| - with no recycling | 1 | | |
| - to evaporation pond | 1 | | |
| - with neutralization | 2 | | |
| - with settling | 2 | | |
| Total Number of Plants Demagging | | | 46 |

## TABLE 17. QUANTITIES OF WASTE WATER GENERATED IN THE WET SCRUBBING OF CHLORINATION FUMES

| Company (code) | Wastewater Generated | |
|---|---|---|
| | l/kg of Mg Removed | (Gal/lb) |
| C-7 | 95.2 | (11) |
| D-6 | 182 | (22) |
| D-8 | 190 | (23) |
| C-26 | 133(1) | (16) |

(1) Estimated from data provided by plant on water usage and rate of Mg removal.

## TABLE 18. CHARACTER OF WASTE WATER FROM CHLORINATION FUME SCRUBBING (No Treatment)

| Parameter | C-7(a) |  | D-6(b) |  |
|---|---|---|---|---|
|  | Conc., mg/ℓ | Loading, grams/KgMg(c) | Conc., mg/ℓ | Loading, grams/KgMg(c) |
| COD | 123 | 12.1 | 536 | 95.8 |
| Total solids | 2910 | 301 |  |  |
| Total dissolved solids | 1885 | 194 | 10,500 | 1856 |
| Total suspended solids | 225 | 22.3 | 480 | 83.0 |
| Sulfate | 11 | 0.51 | 481 | 84.4 |
| Chloride | 4420 | 446 | 8,671 | 1560 |
| Cyanide | <0.02 | 0 | -- | -- |
| Fluoride | 0.24 | -0.08(d) | 0.7 | -0.324 |
| Aluminum | 472 | 50.9 | 6.12 | 0.615 |
| Calcium | 0.12 | -0.215 | 990 | 176 |
| Copper | 0.25 | 0.02 | 1.31 | 0.236 |
| Magnesium | 41.2 | 3.86 | 55.8 | 9.81 |
| Nickel | 0.050 | 0.003 | 0.74 | 0.106 |
| Sodium | 3.11 | -0.007 | 770 | 32.7 |
| Potassium | -- | -- | 206 | 37.1 |
| Zinc | 0.952 | 0.091 | 3.58 | 0.64 |
| Cadmium | 0.066 | 0.006 | 0.30 | 0.054 |
| Lead | 0.061 | 0.004 | 0.24 | 0.025 |
| Manganese | 0.449 | 0.049 | 2.34 | 0.349 |
| Chlorine residue | 0.257 | 0.027 |  |  |
| Oils and grease | 13.9 | 0.590 | 6.24 | 0.403 |
| Phenols (ppb) | 20.7 | -0.002 | -- |  |
| pH | 2.1 | -- | 1.0 | -- |

(a) Average of three composite samples.

(b) Average of five composite samples.

(c) Loading calculated as: $$[\text{conc. effluent (mg/}\ell) - \text{conc. intake (mg/}\ell)] \times \frac{\text{quantity of water used }(\ell)}{\text{quantity of Mg removed (Kg)}}$$

(d) Negative numbers indicate that the process apparently reduced the concentration of this parameter, and are derived from the reports of analytical results as shown above.

(e) Analytical methods from Standard Methods for the Examination of Water and Wastewater, 13th Edition (1971).

loadings vary widely. Raw waste waters (averages of composites) gathered during chlorine demagging have a low pH due to the hydrolysis of anyhdrous aluminum chloride and magnesium chloride that make up the fume. The hydrolysis forms hydrochloric acid, which accounts for part of the high chloride levels present without the associated total dissolved solids. The data at plant C-7 suggests that the chloride in excess of that accountable from aluminum and magnesium had to come from excess chlorine used during demagging. A similar imbalance in operation is suggested by the data on raw waste water for Plant D-6. Unreacted chlorine was measured as residual chlorine in the raw waste water from plant C-7. The effect of pH adjustment and settling on the raw waste water from plant C-7 is described in Section VII.

When chlorine is used for demagging, most of the product is magnesium chloride during the initial phase of the operation, and only a little aluminum chloride is formed. At the temperature of the molten alloy, 760-780°C (1400-1450°F), some of the magnesium chloride is included in the off gases (which may include unreacted chlorine). As the magnesium level is decreased, the chlorine flow is decreased, but more aluminum chloride is formed. When chlorination is done within the furnace, the fumes are usually wet scrubbed through a series of towers. When done in the forewell, the fumes are caught in a bell, contacting the molten metal, and scrubbed with a specially designed aspirator mechanism. The scrubbing is done with and without neutralization of the scrubbing liquid.

When aluminum fluoride is used for magnesium removal, both magnesium fluoride and residual aluminum fluoride remain at the surface of the melt. Both materials are solid at 780°C (1450°F) and exert vapor pressures of less than 1 torr. They do react with water vapor to yield hydrofluoric acid. The recovery of the fumes during demagging is done with fume hoods over the forewell, and the gases are scrubbed with recycled water through venturi-type scrubbers.

Chloride fume scrubber water (when not scrubbed with caustic solution) has a pH of 1.5 and contains hydrolyzed metal chlorides of aluminum, magnesium, and other volatile metal halides such as zinc, manganese, cadmium, nickel, copper, and lead. In alkaline scrubber waters, sodium, potassium, and calcium are present, with a corresponding reduction in the amount of dissolved heavy metals, aluminum and magnesium. The pH range is 9-11. (See Section VII.)

The water from aluminum fluoride fume scrubbing contains HF which is neutralized with caustic. Any metal fluoride or partially hydrolized fluoride particulates would be expected to react in the scrubber system to form insoluble fluorides after pH adjustment. The supernatant should contain fluorides of magnesium and aluminum and perhaps cryolite, all of which are only sparingly soluble. Most of the heavy metal fluorides associated with the alloying metals may end up in the fumes and subsequently in the scrubber sludge.

Fume scrubber water generation is intermittent and coincides with the 1.5-4 hour magnesium removal cycle for each heat (every 24 hours). The water flow rate during the scrubbing ranges between 3,800-12,500 liters (1000-3300 gallons) per hour producing about the same amount of discharge. Of the 27 companies practicing wet scrubbing for air pollution control, scrubbing water is discharged directly (eight each), discharged with recycle (three each), discharged after recycling (two each), recycled continuously (two each) (only those using aluminum fluoride for magnesium removal), discharged to ponds (five each), and recycled and discharged to ponds (two each). Twenty of the 27 companies neutralized the scrubber water and 15 make an effort to remove solids as sludge by settling or by filtration.

## Waste Water From Residue Processing

Sources. Residues used by the secondary aluminum industry are generally composed of 10 to 30 percent aluminum, with attached aluminum oxide fluxing salts (mostly NaCl and KCl), dirt, and various other chlorides, fluorides, and oxides. Separation of the metal from the nonmetals is done by milling and screening and is performed wet or dry. When performed dry, dust collection is necessary to reduce air emissions. Milling of dross and skimmings will produce a dust that, when scrubbed wet, will contain insoluble solids in suspension, such as aluminum oxide hydrated alumina, and soluble salts from the flux cover residues, such as a sodium chloride and potassium chloride. Drosses also contain aluminum nitride, which hydrolyzes in water to yield ammonia. When slags are milled, the waste water from dust control contains more dissolved sodium and potassium chloride and fluoride salts from the cryolite, than from drosses or skimmings. Some of the oxides of heavy metals are solubilized in the slag and leached from the dust.

With wet milling, the dust problem is minimized, but the operation produces a waste water stream that is similar to the scrubber waters in make up, but more concentrated in dissolved solids contaminants. The aluminum and alumina fines are settled rapidly and are used to assist the settling of more difficult to settle components, obtained as sludges from related waste water discharges.

Of the 23 plants recovering aluminum values from residues, eight use wet techniques, which lead to the generation of highly saline waste waters. Table 19 lists the general character of these eight coded plants. Waste water is generated by wet dust removal systems (dust generated by dry milling of residue), the washing of residue fractions (sized), and by wet milling the residue to liberate metallic aluminum. In every case, the waste water is passed into a settling pond before discharge.

Quantities. Water use for the wet milling of residues has been based on the tonnage of aluminum recovery rather than the tonnage

## TABLE 19. RESIDUE WASTE WATER GENERATION AND DISPOSAL PRACTICES

| Practice | Plant Codes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | D-1 | D-2 | D-3 | D-4 | D-5 | D-6 | D-7 | D-8 |
| **Wastewater generated by:** | | | | | | | | |
| Wet dust removal system | X | | X | | | | | |
| Washing of residue fractions | | | | | | X | | |
| Wet milling of residues | | X | X | X | X | | X | X |
| **Disposal of wastewater:** | | | | | | | | |
| Discharge with some recycling | | | | | | | X | X |
| Discharge to settling pond | X | X | X | X | X | X | X | X |
| Chemically treat wastewater to aid settling | | | X | X | | | X | X |
| Discharge to navigable waters via settling pond | | | X | X | | | | X |
| No direct discharge streams from settling ponds | X | X | | | X | X | X | |

of residues processed. This is because the former quantity is generally known more accurately by the smelters than the latter.

Table 20 gives available data on the quantity of waste water generated in the wet milling of residues in liters per metric ton of aluminum recovered. Values for plants D-3 and D-8 are fairly close, while the value for plant D-4 is roughly an order of magnitude higher.

Characteristics. The character of waste water generated during wet milling of residues or residue fractions is given in Table 21. Two plants, D-4 and D-3, had some analytical data on their waste water from Corps of Engineers' permits. To provide better characterization of the waste water, sampling teams were sent to plants D-6, D-8, and D-4 to gather water samples for analysis.

As noted in Table 21, waste water loadings are exceedingly variable. For example, chloride loadings are 0.32, 3264, and 150 kg/kkg (0.64, 6500, and 300 lb/ton) for plants D-3, D-4, and D-8, respectively. This variability is attributed to variation in the salt content in the residues being processed at the time samples were taken. If the dissolved salt (chloride) content is low, drosses from primary aluminum melt operations are being processed (e.g., plant D-3). If they are high, then slags (and drosses or skimmings) from secondary aluminum melting operations are being processed (e.g., plant D-4). Some residue millers operate on a toll, based on the amount of molten aluminum recovered, and process both types of residues. Therefore, there are highs and lows in the dissolved salt content of the waste water depending on the batch of residues being milled. Nontoll millers process both types of residues also, low salt residues for their high aluminum content and home slag for improved aluminum recovery within the plant. In some cases, such plants will also accept slag from secondary smelters not equipped to process their own. The raw waste water as it comes from the mill and screening operation contains large amounts of insoluble solids that settle very quickly. Isolation of the raw discharge stream, to determine the amount of solids present, could not be done; but, it was estimated that the solids content in the waste water is about 30 percent by weight. This would be a highly variable value and dependent upon the type of residue being processed at the time. Settling is a very effective way to remove the insoluble solids. However, there is variation in a plant's ability to remove suspended solids (compare plants D-4 and D-8). Milling at plant D-8 is done with a mixed stream, containing 75 percent alkaline fume scrubber water and 25 percent fresh water. The concentrations reported in Table 18 have been adjusted for this variation and are reported only as the new gain in concentration due to milling. The data suggest that milling with an alkaline stream reduces the ammonia concentration appreciably from that resulting from milling with unaltered intake water (0.30 mg/l vs 350 mg/l for D-4) and suggests an effective way to reduce the level of this pollutant. The mixed stream is also claimed to be effective in reducing the suspended solids load in the pH-adjusted fume scrubber water. The effectiveness is

## TABLE 20. QUANTITIES OF WASTE WATER GENERATED IN THE WET MILLING OF RESIDUES PER TON OF ALUMINUM RECOVERED

| Company (code) | Wastewater Generation ℓ/mton of Al recovered (Gal/ton) |
|---|---|
| D-3 | 16,690(1) |
| D-4 | 218,000 |
| D-8 | 28,838 |

(1) From Corp of Engineers' data.

TABLE 21. CHARACTER OF SETTLED WASTE WATER FROM RESIDUE PROCESSING

| | Plants | | | | | |
|---|---|---|---|---|---|---|
| | D-3[(a)] | D-6[(b)] | D-4[(c)] | | D-8[(d)] | |
| Parameter | Loading (Kg/mton Al) | Conc. (mg/ℓ) | Conc. (mg/ℓ) | Loading (Kg/mton)[(e)] | Conc. (mg/ℓ) | Loading (Kg/mton)[(e)] |
| Alkalinity | 6.47 | 314 | 586 | 102 | 500 | -7.5[(f)] |
| COD | 0.97 | 2,045 | | | 29 | 0.17 |
| Total solids | | | 24,264 | 5,144 | 17,800 | 326 |
| Total dissolved solids | 13.51 | 12,920 | | | 17,400 | 324 |
| Total suspended solids | 0.121 | 4,961 | 15 | 1.5 | 159 | -5.6 |
| Sulfate | | 1,100 | 47 | 1.5 | 151 | 1.8 |
| Chloride | 0.319 | 6,492 | 15,465 | 3,264 | 8,903 | 150 |
| Cyanide | | 0.04 | | | 0.05 | 0 |
| Fluoride | 0.129 | 2.9 | 8.7 | 1.81 | 16.5 | 0.38 |
| Ammonia | 0.33 | 0.75 | 350 | 73 | 0.30 | -0.03 |
| Aluminum | 0.002 | 0.3 | 16.4 | 3.5 | 28 | -1.49 |
| Calcium | | 58.8 | 23 | -7.4 | 48 | 0.17 |
| Copper | <0.001 | 0.174 | 0.070 | 0.008 | 0.137 | 0.003 |
| Magnesium | | 32.5 | 6 | 3.9 | 76 | 1.39 |
| Nickel | | 1.2 | 0.240 | 0.009 | 0.20 | 0 |
| Sodium | | 2,560 | 11,600 | 2,528 | 3,103 | 46.2 |
| Potassium | | 1,087 | 6,470 | 1,407 | 4,802 | 102 |
| Zinc | 0 | 0.015 | 0.10 | 0 | 0.198 | -9.1 |
| Cadmium | | 0.05 | 0.002 | 0 | 0.005 | -0.001 |
| Lead | | 0.20 | 0.020 | 0.004 | 0.028 | -0.001 |
| Manganese | | 0.16 | 0.045 | 0.002 | 0.060 | 0 |
| Chlorine residue | | | -- | -- | -- | -- |
| Oils and grease | 0.053 | 55.4 | 0 | 0 | 0.5 | 0 |
| Phenols (ppb) | | -- | -- | -- | 0.03 | 0 |
| pH | 8.68 | 8.3 | 9.09 | | 9.2 | |
| Nitrates | 0.032 | | | | | |

(a) Calculated from U. S. Corps. of Engineers, concentration data not given.

(b) From residue milling solid waste washing, tonnage values of residue waste processed not available - loading cannot be calculated. Water flow is 151 ℓpm.

(c) Data from 7 month and 9 month average and verification data from state: metals verified composite of 18 samples collected over a period of 6 days.

(d) Represents composite of 9 samples collected over 3 days. Milling waste stream is blended with scrubber waste stream.

(e) Loading calculated as: $[\text{conc. effluent (mg/}\ell) - \text{conc. intake (mg/}\ell)] \times \dfrac{\text{quantity of water used (}\ell)}{\text{quantity of Al recovered from residue (mton)}}$

(f) Negative values indicate that the process reduced the concentration of this parameter and are derived from reported analytical values.

attributed to the rapid settling of the coarser milling wastes, which carry down with them the hydrated alumina and magnesium hydroxide in the treated fume scrubber water, as well as the associated heavy metals. Fluoride in milling waste water is due to the cryolite or aluminum fluoride contained in the slag (flux cover). The presence of aluminates in the alkaline milling water acts on fluoride to limit its concentration. Fluoride content in the slag is also quite variable and depends on the source of the residue being milled at the time. The concentrations of fluoride found in the milling waste water are less than those attainable by the use of lime precipitation.

# SECTION VI

# SELECTION OF POLLUTANT PARAMETERS

## Introduction

The waste water constituents, which have been determined to be present in the process waste waters of the secondary aluminum smelting industry in sufficient quantities to warrant their control and teatment, are listed in Table 22.

This section provides the rationale for the selection, as well as the rejection, of pollutant characteristics for this subcategory.

## Rationale for Selection of Pollutant Parameters

### Cooling Waste Water

The analyses of cooling waste water streams for three plants are given in Table 13, 14, and 15. Examination of the values for the various parameters shows dissolved solids, lead, manganese, and oil and grease to be significantly added to this stream.

### Fume Scrubbing Waste Water

Analyses of two typical waste water streams from fume scrubbing during chlorination are given in Table 18. Examination of the concentration values shows total suspended solids and chemical oxygen demand to be significantly added to this stream. The average pH is noted to be between 1 and 2 and is, thus, a significant pollutant characteristic.

### Residue Milling Waste Water

Analyses of four residue milling waste water streams are given in Table 21. Three of these provide concentration levels. The fourth provides only loading values. From the concentration levels, it is established that total suspended solids, fluoride, ammonia, aluminum, copper, and chemical oxygen demand are significantly added to this stream and are considered as significant pollutants. Total suspended solids, although typically low, can be at high levels, as is the case for plant C-6. Ammonia levels and pH are identifiable as contributions from the process, and are subject to control by currently practicable control and treatment measures.

### pH, Acidity and Alkalinity

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TABLE 22. POLLUTANTS SUBJECT TO EFFLUENT LIMITATIONS

| Treated Wastewater Stream | Pollutant Under Effluent Limitation |
|---|---|
| Wet Milling of Residues | pH<br>Total Suspended Solids<br>Fluoride<br>Ammonia<br>Aluminum<br>Copper<br>COD |
| Fume Scrubbing | pH<br>Total Suspended Solids<br>COD |

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

## Total Suspended Solids

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide carbon dioxide methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.

## Dissolved Solids

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with clealiness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

## Fluorides

As the most reactive non-metal, fluorine is never found free in nature but as a constituent of fluorite or fluorspar, calcium fluoride in sedimentary rocks and also of cryolite, sodium aluminum fluoride in igneous rocks. Owing to their origin only in certain types of rocks and only in a few regions, fluorides in high concentrations are not a common constituent of natural surface waters, but they may occur in detrimental concentrations in ground waters.

Fluorides are used as insecticides, for disinfecting brewery apparatus, as a flux in the manufacture of steel, for preserving wood and mucilages, for the manufacture of glass and enamels, in chemical industries, for water treatment, and for other uses.

Fluorides in sufficient quantity are toxic to humans, with doses of 250 to 450 mg giving severe symptoms or causing death.

There are numerous articles describing the effects of fluoride-bearing waters on dental enamel of children; these studies lead to the generalization that water containing less than 0.9 to 1.0 mg/l of fluoride will seldom cause mottled enamel in children, and for adults, concentrations less than 3 or 4 mg/l are not likely to cause endemic cumulative fluorosis and skeletal effects. Abundant literature is also available describing the advantages of maintaining 0.8 to 1.5 mg/l of fluoride ion in drinking water to aid in the reduction of dental decay, especially among children.

Chronic fluoride poisoning of livestock has been observed in areas where water contained 10 to 15 mg/l fluoride. Concentrations of 30 - 50 mg/l of fluoride in the total ration of dairy cows is considered the upper safe limit. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree and it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish at concentrations higher than 1.5 mg/l.

## Ammonia

Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate ($NO_3$) by nitrifying bacteria. Nitrite ($NO_2$), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

Nitrates are considered to be among the poisonous ingredients of mineralized waters, with potassium nitrate being more poisonous than sodium nitrate. Excess nitrates cause irritation of the mucous linings of the gastrointestinal tract and the bladder; the symptoms are diarrhea and diuresis, and drinking one liter of water containing 500 mg/l of nitrate can cause such symptoms.

Infant methemoglobinemia, a disease characterized by certain specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate nitrogen ($NO_3$-N) should not be used for infants. Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer. In most natural water the pH range is such that ammonium ions ($NH_4^+$) predominate. In alkaline waters, however, high concentrations of un-ionized ammonia in undissociated ammonium hydroxide increase the toxicity of ammonia solutions. In streams polluted with sewage, up to one half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l un-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and fish may suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 mg/l to 25 mg/l, depending on the pH and dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

Copper

Copper salts occur in natural surface waters only in trace amounts, up to about 0.05 mg/l, so that their presence generally is the result of pollution. This is attributable to the corrosive action of the water on copper and brass tubing, to industrial effluents, and frequently to the use of copper compounds for the control of undesirable plankton organisms.

Copper is not considered to be a cumulative systemic poison for humans, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. Threshold concentrations for taste have been generally reported in the range of 1.0-2.0 mg/l of copper, while as much as 5-7.5 mg/l makes the water completely unpalatable.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts is reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and cadmium are synergistic in their toxic effect on fish.

Copper concentrations less than 1 mg/l have been reported to be toxic, particularly in soft water, to many kinds of fish, crustaceans, mollusks, insects, phytoplankton and zooplankton. Concentrations of copper, for example, are detrimental to some oysters above .1 ppm. Oysters cultured in sea water containing 0.13-0.5 ppm of copper deposited the metal in their bodies and became unfit as a food substance.

Oil and Grease

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

## Chemical Oxygen Demand

The chemical oxygen demand is a measure of the quantity of the oxidizable materials present in water and vaires with water composition, temperature, and other functions. Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high COD can kill all inhabitants of the affected area.

If a high COD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

## Rationale for Rejection of Other Waste Water Constituents as Pollutant Parameters

Waste water from the three unit operations, metal cooling, demagging fume scrubbing and residue milling, were characterized in a limited way prior to the sampling and analysis, as conducted in this study. The choice of possible pollutant parameters for which analyses were to be made was based on information supplied to the Corp of Engineers for permits to discharge under the Refuse Act Permit Program and on an understanding of the chemistry associated with each operation waste stream. Some of these parameters were rejected as significant pollutants. The reasons for rejection were that either the process did not contribute to the presence of such constituents or that the concentrations of certain constituents, namely oil and grease for all process waste water sources except cooling, were considered to be too small in magnitude to be significantly reduced by current technology.

# SECTION VII

# CONTROL AND TREATMENT TECHNOLOGY

## Introduction

The control and treatment technology for reducing the discharge of pollutants in waste water from metal cooling, fume scrubbing, and residue milling is discussed in this section. The discussion includes control and treatment alternatives for each type of waste water stream and identifies process modifications to reduce or eliminate the discharge of water.

## Waste Water From Metal Cooling

The major pollutant in the waste water generated during the cooling of ingot molds, containing molten alloy, are oil and grease and suspended and dissolved solids. The oil and grease, used to lubricate mold conveyor systems, is washed from equipment as the ingots are sprayed from the underside with water. The water is collected in a pit, which is drained to a sump. The dissolved solids and suspended solids are attributable to poor housekeeping in the area of the cooling pit. In those operations where cooling water is spray-cooled before recycling, dust is removed from the air in the vicinity of the plant. The production of deoxidizer shot differs from ingot cooling, in that the molten metal shot contacts the water as it is quenched. During the quench, some aluminum reacts with the water to eventually form a sludge.

Typically, cooling waste water is discharged by the secondary aluminum smelters without prior treatment. Many of the smelters control the discharge of cooling waste water through continuous recirculation or by adjusting water flow, so that total consumption (evaporation) takes place. Others have avoided water usage completely through the use of air cooling.

### Control Alternatives

The amount of waste water generated from metal cooling can be reduced by recirculation and cooling. A waste water discharge could be eliminated by adopting a concept of either total consumption through regulated flow or air cooling. However, the latter two alternatives are not suited to smelters producing deoxidizer shot.

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**Recirculation.** Of 58 secondary smelters canvassed which generate cooling waste waters, 15 are recirculating the water continuously, with no discharge whatever. Seven others are recycling the cooling water but discharge the holding tanks periodically, usually at six-month intervals. The reason for the discharge is to permit sludge removal from cooling towers and pits. A flow diagram for a recirculating system is given in Figure 3.

Discussions with smelter personnel have indicated that it is possible to discharge the cooling water into an auxiliary holding tank to permit sludge removal from the main system. The water could then be returned to the system after sludge removal.

Installation of a recirculation system involves the construction of a cooling tower, possible enlargement of the cooling pit, an auxiliary holding tank, associated plumbing, and necessary pumps. The size and cost of these facilities would depend on the production capacity of the smelter. Generally, this type of equipment has been engineered, built, and installed by smelter personnel. Because of this, it is difficult to obtain accurate cost data. Estimates have run from $2000 to $5000 for the spray cooling, water storage pit, pumps, and associated plumbing to provide enough capacity for a smelter with an output of about 0.454 million kg (1 million lb) of alloy per month.

Maintenance on the recirculation system is largely due to sludge buildup. This involves approximately four man-days every six months. Very seldom are any maintenance problems mentioned in connection with the recirculation system itself. The amount of sludge buildup appears to vary from plant to plant. Those that do not have a sludge problem claim to recirculate their cooling water continuously and must replenish the water that has evaporated. They attribute the sludge buildup by others to poor housekeeping more than removal of solids from the air. Similar comments were made about dissolved salts; however, as their concentration increases, total evaporation of cooling water through flash cooling on hot ingots may be a viable disposal alternative. Oil and grease accumulation would appear to be unavoidable. However, at these higher concentrations of oil and grease, removal by skimming is facilitated. Use of more expensive greases that melt at higher temperatures and are less prone to erosion have been suggested as a means of controlling this pollution problem.

**Total Consumption of Cooling Water.** Of the 58 smelters using cooling water, three have reduced the flow rates such that the water is essentially totally evaporated by the hot ingots. As such, no waste water is generated. Specially designed nozzles exist to give a water-mist spray, that reduces the steam-to-metal interface. However, these nozzles are inclined to get plugged with dirt and, thereby, present a maintenance problem. Such approaches require longer conveyors to assure that the ingots have cooled sufficiently to be handled.

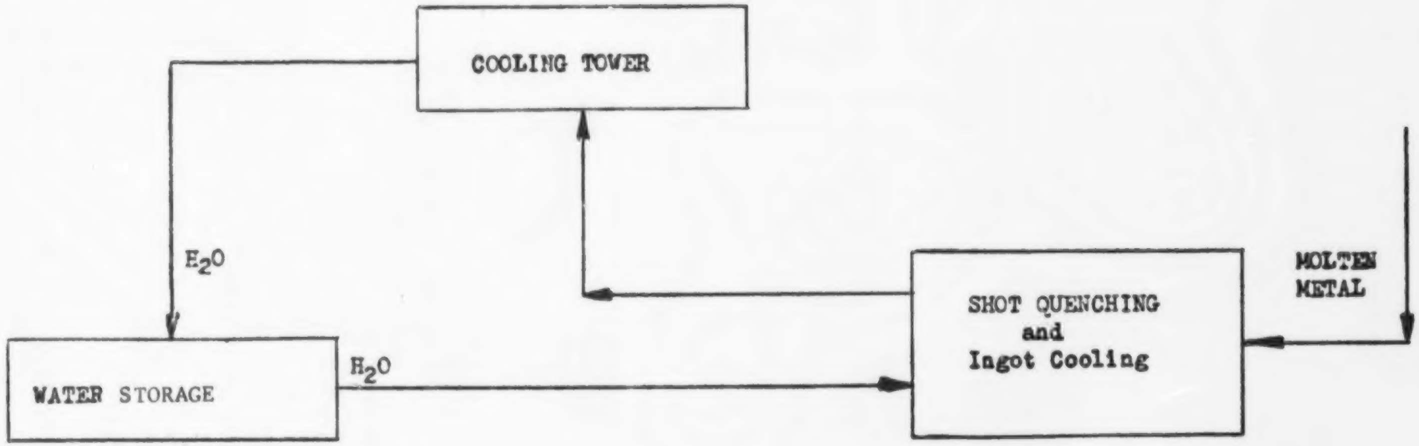
COOLING TOWER
MOLTEN METAL
$H_2O$
SHOT QUENCHING and Ingot Cooling
WATER STORAGE
$H_2O$

Figure 3. Recirculated cooling water system.

Air Cooling. Of the 69 secondary smelters canvassed, 13 are air cooling their ingots and sows. Air cooling is accomplished by conveying the hot ingots through an air tunnel, fitted with entrance and exhaust blowers. The conveyors need to be approximately twice the length of water cooling conveyors. Maintenance is higher on the air-cooled system because of the longer conveyor, the added heat load on the lubricants, and the additional blower motors. In some cases a water mist is added to the air to improve the cooling rate. The water is completely evaporated.

## Treatment Alternatives

The waste water from cooling operations requires treatment to remove the oil and grease and suspended solids before discharge. This holds for once-through water and for recirculated water. As in most treatment processes, it is less difficult to treat waste water with high concentrations of pollutants than those with low concentrations. Therefore, treatment of recirculated water would be preferable.

Oil and Grease. Specialized skimming devices are available for the removal of oil and grease pollutants from water. Grease (and oil) traps can reduce the levels, so that such specialized equipment is not overloaded.

Solids Separation. Both dissolved and suspended solids are added to the cooling waste water. Removal of suspended solids requires settling, which is very slow at low concentrations, but can be made more rapid at high concentrations. The components of the suspended solids are primarily aluminum hydroxide or hydrated oxide which are known to be excellent coagulants. Recirculation of cooling water will build the suspended solids level to concentrations great enough to effect rapid settling between cooling operation cycles. Sludge is removed periodically, usually every 6 months. However, others have claimed no need to remove sludge since buildup was not detected. The supernatant water is of sufficiently good quality that it can be pumped into a holding tank during sludge removal from the settling tank or pit and then reused. The latter procedure appears to be more in line with a process that evaporates water and which is constantly replenished. For example, a settling tank or pit with about 37,850 liters (10,000 gallon) capacity and a holding tank of comparable size would be required to supply water for a 15 metric ton per day (17 ton) ingot casting operation. Billet "direct chill" cooling and shot cooling require, typically, about a 3.785 million liter (1.0 million gallon) capacity system.

Sludge from the settling tank, which amounts to about 757 to 7,570 liters (200 to 2000 gallons) every 6 months, is disposed of in sanitary sewers, storm sewers, lagoons, ponds or simply dumped onto slag, destined for land disposal or reprocessing. Since the sludge is primarily hydrated alumina, the nonwater environmental impact is considered to be negligible. Disposal in land fills, after dewatering by filtration, would be the ultimate means of sludge disposal. The filtrate would be recycled or discharged to the sanitary sewers.

## Waste Water From Fume Scrubbing

The fumes formed during chemical magnesium removal must be controlled to reduce air emissions to acceptable levels. Wet scrubbing techniques have been employed for this purpose and take numerous forms, some of which are considered to be proprietary. The discharge from these wet fume scrubbing devices contains most of the volatile metal salts entrained in the gas flow. When chlorine is used for magnesium removal, aluminum chloride and magnesium chloride are the principal constituents, while chlorides of the other alloying elements are also found due to entrainment. When aluminum fluoride is used for magnesium removal, the principal volatile products may be silicon tetrafluoride and hydrogen fluoride which is formed from the high-temperature hydrolysis of the slightly volatile fluoride salts reacting with moisture in the air. In both cases, the air pollutants are transferred into water pollutants. In the case of chloride fume scrubbing, the salts are mostly soluble in water. In the case of fluoride fume scrubbing, the salts are only slightly soluble, but the hydrolysis product, hydrogen fluoride is very soluble.

## Control Alternatives

Control of air emissions during magnesium removal can be done dry as well as wet. Dry emission control techniques must contend with rather corrosive gases for both types of magnesium removal. Anhydrous chloride salts hydrolyze to produce hydrogen chloride gas, which in turn reacts with water vapor to form hydrochloric acid. Hydrogen fluoride and hydrofluoric acid are formed only at high temperatures; however, once formed, they remain in the gases being scrubbed.

*Fume Control*. Three processes exist for reduction and/or removal of fumes without major use of water either in the process or in fume control. These are the Derham process, the Alcoa process, and the Teller process.

*The Derham Process*.(1) The Derham process includes equipment and techniques for magnesium removal, with chlorine, from secondary aluminum melts with a minimum of fume generation and without major use of water in either the process or in fume control. The principal concept is the entrapment of magnesium chloride, the reaction product of magnesium removal, in a liquid flux cover, with the flux being subsequently used in the melting operations.

The elements of the Derham process are indicated in Figure 4. The principal components consist of a separate bath of the metal to be treated with its special flux cover, and means to circulate the molten metal to and from that separate bath.

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(1) Mention of trade names or specific products does not constitute an endorsement by the Environmental Production Agency

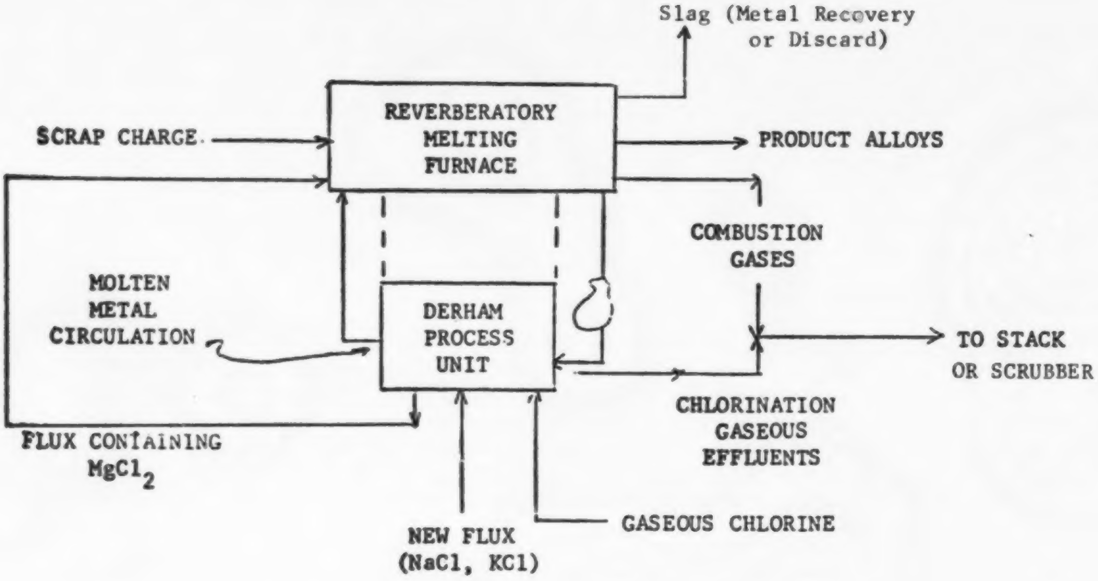
Slag (Metal Recovery or Discard)
REVERBERATORY MELTING FURNACE
SCRAP CHARGE
PRODUCT ALLOYS
COMBUSTION GASES
MOLTEN METAL CIRCULATION
DERHAM PROCESS UNIT
TO STACK OR SCRUBBER
CHLORINATION GASEOUS EFFLUENTS
FLUX CONTAINING MgCl2
GASEOUS CHLORINE
NEW FLUX (NaCl, KCl)

Figure 4. Schematic diagram of elements of the Derham Process.

The treatment bath may be integral with the smelting furnace or separate, depending on whether the particular installation is a new facility or the equipment is being installed on existing equipment. The molten metal circulation from the main furnace hearth to the Derham unit is accomplished by pumping (usually with an air driven siphon) rather than by less direct methods, such as mechanical stirring or nitrogen gas sparging or agitation. The molten metal brought to the treatment unit is treated in the usual manner with gaseous chlorine to achieve magnesium removal, resulting in the generation of molten magnesium chloride as the reaction product. By maintaining a relatively thick cover of molten salt on the bath in the treatment unit, the emissions of aluminum chloride to the atmosphere, usually produced by demagging, are nearly completely arrested. As the flux cover becomes saturated with respect to magnesium chloride, it is removed and may be used as a flux in the main melting furnace.

Any gaseous effluents from the treatment unit are blended with the combustion gas effluent and released to the stack. Emission control requirements vary, and may be satisfied by blending the gases. In situations requiring particulate control with baghouses, the chloride emissions, although hygroscopic, are usually dilute enough not to interfere with baghouse operation.

Associated engineering features, reported for this process, include the significant reduction of fuel requirements and melting time resulting from metal circulation. Heat transfer rates from the center hearth to the charging well are increased, so that temperature gradients are decreased. The usual gradient was quoted as being 200°F between charging well (1300°F) and melt (1500-1600°F). With metal circulation, this is reduced to 150°F. The increase in melt rate was quoted as at least 20 percent.

The efficiency of chlorination is reported to be nearly stoichiometric down to 0.1 percent magnesium in the melt. This is better than ordinary chlorination rates, which are 50-60 percent efficient at the lower range of magnesium content. No adverse effects on product quality are reported. One user, employing the process for degassing only (rather than demagging), reports improved metal quality in the application of the process in an extrusion plant.

The Derham process is generally satisfactory in terms of meeting air pollution restrictions. Although a second scrubber may be desirable under stringent regulations and/or transient process conditions, the loading should be very low. Water use would not be completely eliminated, but recycling of water could be done more easily.

*The Alcoa Process.*(1) The Aluminum Company of America is allowing the licensing of a "fumeless" demagging process, that claims achievement of 100 percent efficiency in chlorine utilization for magnesium removal. It recovers molten magnesium chloride as a product. At present, it is being used in England for captive scrap processing. The unit is installed between the holding furnace and a casting machine and removes magnesium continuously as the metal flows through.

The operation uses no flux salts and attains the high chlorine efficiencies by means of extended gas residence times provided by gas-liquid contactors. For very dirty scrap, a short period of prechlorination in the furnace is necessary to improve fluxing. The system has been operated on a commercial scale at an alloy flow rate of 5900 kg (13,000 lb) per hour, with a magnesium removal rate of 27 kg (52 lb) per hour. Magnesium content was reduced from 0.5 to 0.1 percent.

Coated Baghouse (Teller) Process.(1) Baghouses have not been effective in the removal of fumes from demagging operations. Blinding occurs during collection of submicron particulates. These particles enter the interstices of the weave and create a barrier to gas flow. When blinding occurs, the pressure drop rises rapidly, and gas flow diminishes.

The Teller modification of baghouse operation has been described in varying detail, since the inventor considers most information proprietary (Teller, 1972). Only one system has been installed at a secondary aluminum smelter. Basically, the system differs from a normal baghouse in that the bags are precoated with a solid to absorb effluent gases as well as particulates, supposedly without blinding. Upon saturation, the coating is removed along with the collected dust by vibration. A fresh coating is then applied. The collected particulate and spent coating are to be disposed of in a landfill. The system is suited for collection of emissions from operations using aluminum fluoride for demagging. A prototype has been installed in such a facility, where its performance is being evaluated. The evaluation program should also establish its effectiveness for the collection of emissions from operations using chlorine for demagging.

The proprietary system, in the case of fluoride emissions from glass furnaces, is based on simultaneous filtration and chromatographic absorption and baghouse recovery. The chromatographic solid is injected into the gas duct and is then separated from the gas in a baghouse. The solid serves as an absorbent for acid gases and as a baghouse precoat to prevent blinding. The reactive carrier coats the bags and acts as a filtration precoat. It breaches, rather than blocks, the interstices and acts as the actual filter, using the bag surface only as a support. This is the principle of the precoat action.

The chromatographic material consists of a monomolecular layer of reagent on a reactive carrier. In one application, the carrier cost was estimated to be $30 per metric ton. In the absorption of hydrogen fluoride it can provide one transfer unit in 0.0254 cm (0.01 inch) depth of the chromatographic material. With a duct line injection rate of 0.454 to 0.908 kg per 280 cu m (1 to 2 lb per 10,000 cu ft) of gas, 80-90 percent removal of hydrogen fluoride occurred in the duct and 99 percent in the baghouse collector.

The recovered solids, consisting of the original chromatographic material, neutralized gaseous fluorides, and the particulates from the operation can either be recycled (if the discharge is compatible with feed material being charged to the operation) or it can be removed to a landfill.

In order to apply the Teller process to specific secondary aluminum operations, the nature and the variability of the emission with the types of scrap, and/or the ratio of scrap types being charged, as well as the rate of magnesium removal, must be established. To be comprehensive, such a study would require considerable expenditure.

## Treatment Alternatives

Of the 69 facilities canvassed, 46 use demagging to prepare alloys (see Table 23). Of these, 29 employ some form of wet scrubbing to control air emissions. Three use aluminum fluoride and 26 use chlorine for demagging. A number of the smaller volume operations have delayed installing wet air pollution control devices until water standards are more clearly defined. In one case, a wet scrubber system has been employed for smoke abatement, since restrictions on fuel consumption have ruled out the use of afterburners. No demagging was done at this plant.

Removal of fumes formed during demagging from the air by wet scrubbing techniques transfers the pollutants to water. Disposal and treatment prior to disposal or reuse are dictated by the method used for magnesium removal from the molten metal. When chlorine is used, the anhydrous salts hydrolyze during scrubbing to form acidic solutions of chloride salts, which even after neutralization preclude reuse of the water continuously without buildup of high levels of salt concentration. When aluminum fluoride is used, scrubbing of the fumes with water produces fluorides in solution. Subsequent treatment can assure the formation of slightly soluble salts, that do not increase their concentration in water, making continuous recycle of water possible after settling.

Discharge practices and treatment practices, used on both types of waste water, are given in Tables 24 and 25 and are described in the following sections.

**Chloride Fume Scrubber Waste Water.** The water from fume scrubbing operations, using chlorine for demagging, are highly acidic, due to the hydrolysis of aluminum chloride and magnesium chloride. Four plants are discharging directly into sanitary sewers without treatment. Three discharge into sewers after neutralization, and four after neutralization and solids removal by settling. Such an effluent provides a source of partially soluble aluminum and

TABLE 23. MAGNESIUM REMOVAL PRACTICE (DEMAGGING) USED BY SECONDARY ALUMINUM INDUSTRY

| Chemical Used | Number of Smelter Plants Using Magnesium Removal | Number of Smelter Plants Using Wet Scrubbing to Control Emission During Demagging |
|---|---|---|
| Aluminum Trifluoride | 14 | 3 |
| Chlorine | 32 | 26 |
|  | 46(a) | 29(b) |

(a) Of this total, 4 use both methods for magnesium removal.

(b) Of this total, 2 use both methods for magnesium removal.

## TABLE 24. TREATMENT OF EFFLUENTS FROM FUME SCRUBBING (DISCHARGED AS NOTED)

Number of Smelters Using Given Practice

| Treatment | Neutralize | Neutralize Solids Removal | | Solids Removal | No Treatment |
|---|---|---|---|---|---|
| | | $Cl_2$ | $AlF_3$ | | |
| Effluent Control | | | | | |
| Discharge Directly | | | | | |
| No Recycle | 2 | 5 | - | 1 | 4 |
| With Recycle | - | 3 | - | - | - |
| After Recycle | 1 | 1 | - | - | - |
| Total | 3 | 9 | 0 | 1 | 4 |
| Discharge to: | | | | | |
| Stream | 1 | 4 | - | - | - |
| Sanitary Sewer | 3 | 4 | 1 | - | 4 |
| Total | 4 | 8 | 1 | 0 | 4 |

## TABLE 25. TREATMENT OF EFFLUENTS FROM FUME SCRUBBING (NO DISCHARGE)

| | Number of Smelters Using Given Practice | | | | |
|---|---|---|---|---|---|
| | | Neutralize Solids Removal | | | |
| Treatment | Neutralize | $Cl_2$ | $AlF_3$ | Solids Removal | No Treatment |
| Effluent Control | | | | | |
| Recycled Continuously | - | - | 2 | - | - |
| Discharge into Pond | 1 | 2 | 1 | 2 | 2 |
| Recycle and Discharge to Pond | 1 | 1 | - | - | - |
| Total | 2 | 3 | 3 | 2 | 2 |

magnesium salts, which are suitable for coagulation and precipitation treatment.

Neutralization to a pH of 6.0-7.0 will precipitate most of the aluminum and magnesium as hydroxide. Coprecipitation of heavy metal hydroxides also occurs. The effectiveness of neutralization is diminished if too much alkali is added, since dissolution of aluminum hydroxide occurs at about pH 9. The data presented in Table 26 indicate that this is true. When neutralization follows the scrubbing, as is shown in the flow diagram of the treatment of chloride scrubber water in Figure 5, not all of the aluminum is precipitated when the pH is raised to 9.0-9.2. This could, in part, be due to over treatment with alkali, causing dissolution of the aluminum hydroxide. The scrubbing operation is done directly with an alkaline solution at plant D-8, and the data suggest that the aluminum loading is high, due to the high pH. The heavy metals are decreased; however, due to the high pH, the total solids and sodium loading is increased. Smelter personnel using pH control instrumentation for alkali feed claim that they are unreliable and require frequent maintenance. Under conditions of failure, overneutralization occurs.

The effluents from chloride scrubbers are also discharged into streams. Four smelters neutralize and remove solids by settling before discharging into navigable waters. Two discharge with recycling, and two discharge directly after neutralization and settling to remove solids.

Effluents are also discharged to ponds with impermeable to semipermeable surfaces, both with and without neutralization. Solids are removed periodically after evaporation of the water. One practice is to recycle the neutralized water through the scrubber until it is too difficult to pump. The slurry is then discharged to the pond. Another practice is to employ a settling tank for neutralization, from which the supernatant is discharged into the evaporation pond and is recycled to the scrubber, as needed. The settling tank was drained weekly into the pond in order to remove the sludge accumulation of 625 liters (165 gallons). The flow diagram of a facility employing an evaporation pond in this manner is shown in Figure 6.

Aluminum Fluoride Fume Scrubber Water. Three of the 14 smelters, using aluminum fluoride for magnesium removal, use wet scrubbing for air emission control. Two of the three recycle the water continuously and neutralize the solution with sodium hydroxide. The other plant also neutralizes the waste water, but since both chlorine and aluminum fluoride are used at this plant, the effluent is discharged to a lagoon.

The continuous recycle system shown in Figure 7 scrubs the emissions with a venturi-type scrubber, followed by a packed tower and demisting chamber. The waste water is collected in a settling tank, where it is treated with 5 percent caustic to neutralize hydrogen fluoride formed from hydrolysis. The sodium

## TABLE 26. EFFECT OF NEUTRALIZATION AND SETTLING ON SCRUBBING WASTE WATER LOADING

| Parameter | Waste Loadings, gram of pollutant/kg of Mg removed | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plant C-7 (Case I) | | | Plant C-7 (Case II) | | | Plant D-6 | Plant D-8 |
| | Before Treatment | After Treatment | Net Effect | Before Treatment | After Treatment | Net Effect | No Treatment | Alkali Treatment No Settling |
| Alkalinity | | 1.8 | | | 5.47 | | | 2754 |
| COD | 20.1 | 6.09 | -14.0 | 2.58 | 6.84 | 4.26 | 95.8 | 1.52 |
| Total Solids | 684 | 999 | 315 | 77.4 | 450 | 372 | | 4864 |
| Total Dis. Solids | 453 | 710 | 257 | 42.0 | 382 | 340 | 1856 | 3772 |
| Total Sus. Solids | 45.1 | 284 | 239 | 16.9 | 66 | 49.1 | 83 | 1193 |
| Sulfate | 1.03 | .115 | -.92 | .402 | .402 | 0 | 89.4 | 41 |
| Chloride | 775 | 443 | -332 | 200 | 234 | 34 | 1560 | 851 |
| Cyanide | 0 | 0 | 0 | 0 | .047 | .047 | -- | 0 |
| Fluoride | -.108 | .053 | .161 | -.064 | -.053 | .011 | -0.324 | -0.3 |
| Aluminum | 124 | 66.7 | -57.3 | 13.5 | 15.1 | 1.6 | 0.615 | 184 |
| Calcium | -.260 | -.260 | 0 | -.182 | -.182 | 0 | 176 | -0.21 |
| Copper | .024 | .010 | -.014 | .017 | .007 | -.01 | 0.236 | 0.01 |
| Magnesium | 6.03 | 2.01 | -4.02 | 2.86 | 1.30 | -1.56 | 9.81 | 6.02 |
| Nickel | .008 | .008 | 0 | .002 | .005 | .003 | 0.106 | 0 |
| Sodium | .002 | 261 | 261 | 0 | 143 | 143 | 32.7 | 1919 |
| Zinc | .140 | .058 | -.082 | .053 | .036 | -.017 | 37.1 | 1.38 |
| Cadmium | .009 | .005 | -.004 | .004 | .002 | -.002 | 0.64 | 0.12 |
| Lead | .009 | .009 | 0 | 0 | .006 | .006 | 0.054 | -0.02 |
| Manganese | .132 | .011 | -.121 | .011 | .006 | -.005 | 0.025 | 0.01 |
| Chlorine Residue | .078 | 0 | -.078 | 0 | 4.2 | 4.2 | 0.349 | -- |
| Oil & Grease | -.242 | .426 | .668 | 1.85 | 3.5 | 1.65 | -- | 0 |
| Phenols (ppb) | -.003 | -.002 | .001 | -.001 | -.002 | -.001 | 0.403 | 0.02 |
| pH | 1.7 | 9.2 | | 1.7 | 9 | | 1.0 | 9.5 |

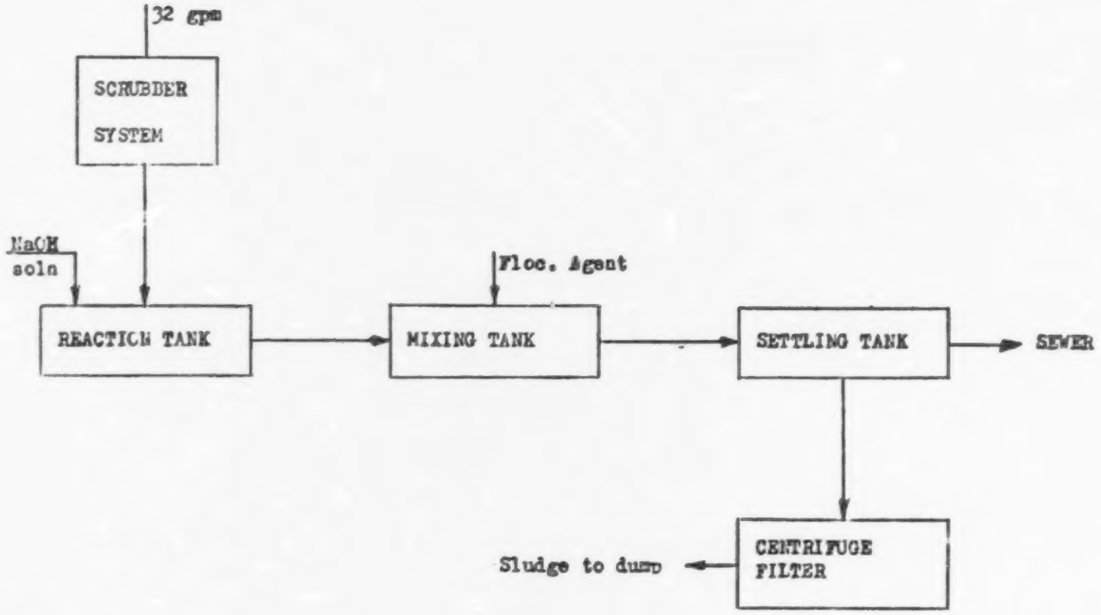
32 gpm
SCRUBBER SYSTEM
NaOH soln
REACTION TANK
Floc. Agent
MIXING TANK
SETTLING TANK
SEWER
CENTRIFUGE FILTER
Sludge to dump

Figure 5. [illegible]oride fume scrubber waste water treatment (neutralization-settling).

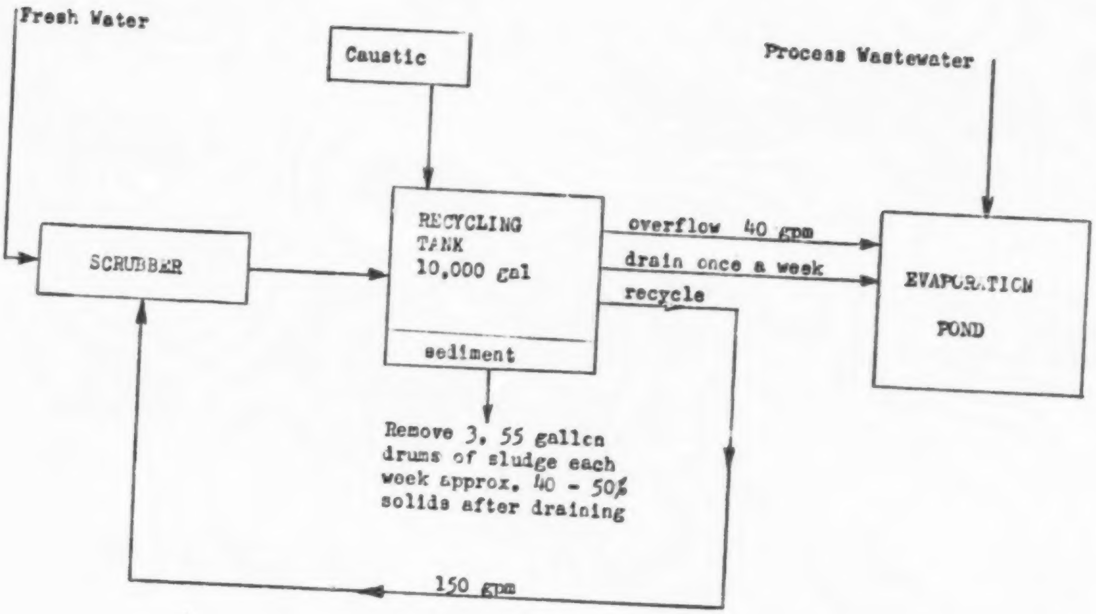
Fresh Water
Caustic
Process Wastewater
SCRUBBER
RECYCLING TANK 10,000 gal
sediment
overflow 40 gpm
drain once a week
recycle
EVAPORATION POND
Remove 3, 55 gallon drums of sludge each week approx. 40 - 50% solids after draining
150 gpm

Figure 6. Chloride fume scrubber treatment (partial recycle and evaporation pond discharge).

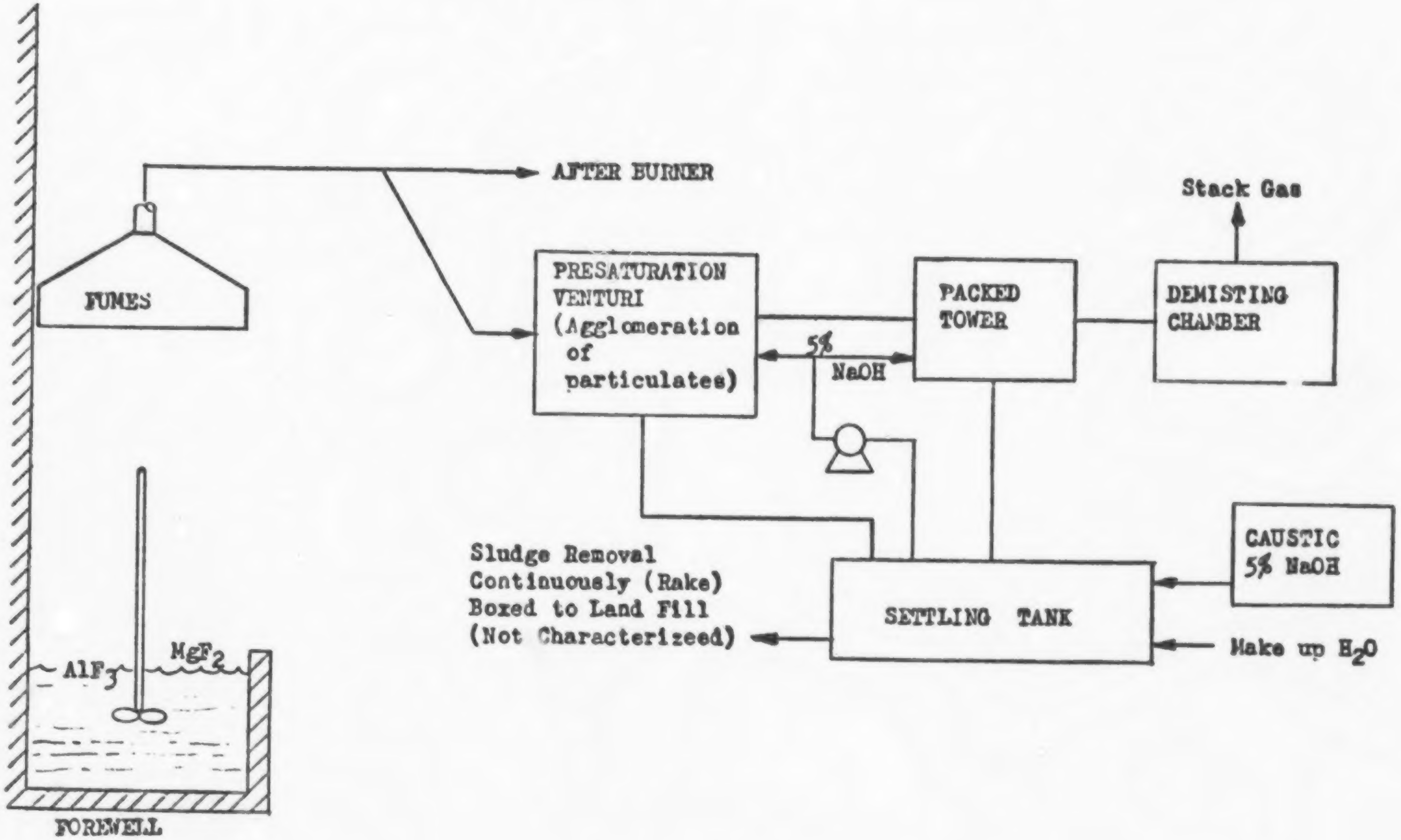
AFTER BURNER
Stack Gas
FUMES
PRESATURATION VENTURI (Agglomeration of particulates)
PACKED TOWER
DEMISTING CHAMBER
5% NaOH
Sludge Removal Continuously (Rake) Boxed to Land Fill (Not Characterizeed)
SETTLING TANK
CAUSTIC 5% NaOH
Make up H2O
AlF3
MgF2
FOREWELL

Figure 7. Aluminum fluoride fume scrubber system with continuous recycle.

fluoride formed reacts with particulate aluminum fluoride carried with the emission, to form insoluble cryolite. The magnesium fluoride which may also be carried with the air stream, cryolite, and other insolubles are separated in settling tanks, and the alkaline supernatant is recycled to the scrubber system. The plant personnel claim that there is no water discharged except for that removed with the sludge, which is discarded in landfills. The installation was designed for operation on one furnace, but plans are to use the system for the three remaining furnaces. Special retractable panels are being installed to improve air flows over the forewell for emission control. Until these improvements are made, the system remains idle.

## Waste Water From Residue Milling

Water is used by six of the 23 smelters that process residues to recover metallic aluminum values. Depending on the nature of the residue being milled, the amounts of dissolved solids and insoluble solids in the raw waste water vary. When the residues are slags from secondary smelters, the waste water is very high in dissolved salts. When the residues are drosses or skimmings from primary or foundry sources, the amount of dissolved salts in the waste water is greatly reduced; however, the insoluble solids fraction in the dross approaches 70 percent by volume. At most residue milling facilities, both types of residues are handled, and both types of raw waste water are generated from the same milling operation. Waste water is also produced from the wet control of dust generated by a dry milling operation producing a low salt, high aluminum product of the solid waste from the dry milling of residues.

### Current Practice

Waste water generated during wet milling of residues is treated in settling ponds, in which the insoluble materials are removed. No control of the dissolved salts is practiced by the two plants discharging into streams and the one discharging into municipal sewers. Some dissolved salt control by evaporation is claimed by those discharging the waste water into lagoons. Four smelters, with waste water from residue milling, use such lagoons.

In one plant, all milling residues less than 60 mesh are discharged for treatment in settling ponds. The first stage, of a four stage pond system, is treated with a polyelectrolyte to improve settling. A fourth settling pond, with skimmers, discharges the clear overflow into the midcourse of the receiving stream. The sludge from the fourth stage is recycled back into the first pond and is removed with the aid of the material passing through 60 mesh. The insoluble residue is disposed of through sales or through an industrial disposal contractor. Residues stored outside are subject to leaching by the rain, and the runoff is directed into the plant drainage ditch and the fourth pond.

In another operation shown in Figure 8 (Plant D-8), the discharge from the milling operation, which contains the insoluble materials after metallic aluminum was removed, is used to accelerate settling of alkaline scrubber solutions from chloride fume scrubbing waste water discharged into the same ponds. Because of the mixing occurring in the waste water circuit, the benefits of this treatment on scrubber waste water loading could not be determined.

## Control Alternatives

The alternative to wet residue milling and the resulting waste water treatment is dry milling of the residues. Seventeen of the 23 residue processors practice dry milling to eliminate waste water. Impact mills, grinders, and screening operations are used to remove the metallic aluminum values from the nonmetallic values. The high levels of dust formed in these operations are vented to baghouses. The baghouse dust and the nonmetallic fines from the screening constitute the solid waste from the operation. These are stored on the plant site on the surface of the ground. Attempts are made to control the runoff by containing dissolved salts in drainage ditches. Contamination of surface and subsurface waters is unavoidable as the solid waste handling is practiced now. Markets for the "field leached waste" are developing in the cement industry, since the waste consists mostly of impure aluminum oxide. The purity is claimed to be too low for use as a substitute for bauxite ore.

Those practicing dry dross milling in areas where land for solid waste disposal of the waste is limited are using the services of industrial waste disposal contractors.

## Treatment Alternatives

Wet milling of primary aluminum residues and secondary aluminum slags by a countercurrent process is claimed by certain segments of the industry as the only way to reduce or possibly eliminate salt impregnation of ground and runoff water from the discarded solid waste. By using a countercurrent milling and washing approach, two advantages could be realized. The final recovered metal would be washed with clean water providing a low salt feed to the reverberatory furnaces. The waste water, with the insolubles removed, would be of a concentration suitable for economical salt recovery by evaporation and crystallization. Heat for evaporation could be supplied by the waste heat from the reverberatory furnaces. The process would have to contend with the ultimate disposal of the dirt, trace metals, and insolubles recovered from the brine, which should contain very low levels of soluble salts. Such salt recovery installations are operating in England and Switzerland, and the salts recovered assist in paying

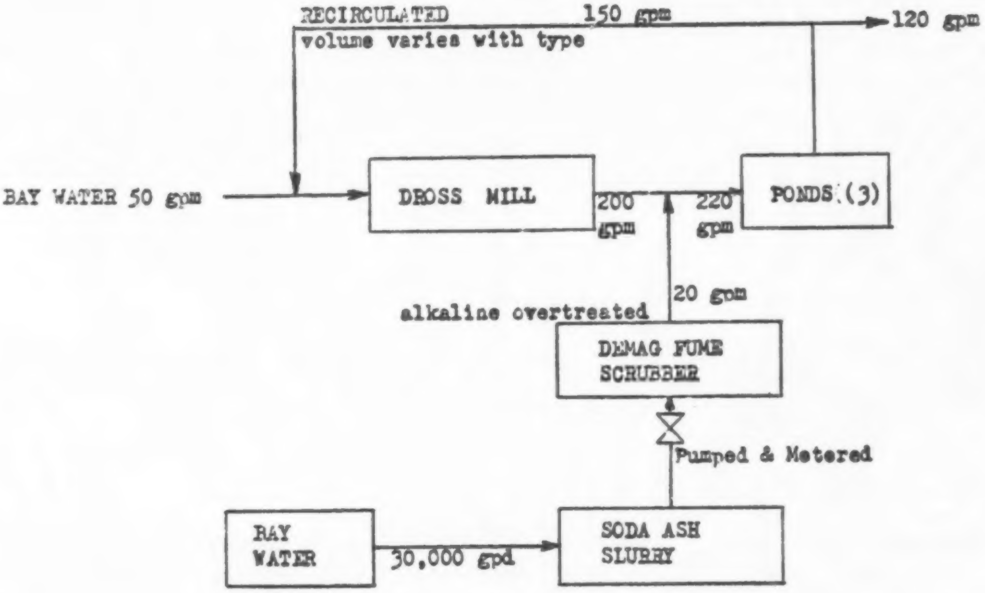
RECIRCULATED
150 gpm
120 gpm
volume varies with type
BAY WATER 50 gpm
DROSS MILL
200 gpm
220 gpm
PONDS (3)
20 gpm
alkaline overtreated
DEMAG FUME SCRUBBER
Pumped & Metered
BAY WATER
30,000 gpd
SODA ASH SLURRY

Figure 8. Residue milling and alkaline chloride fume scrubber waste water treatment system.

for the operation, since they are reusable as fluxing salts in the secondary aluminum industry. Such a system has not been put into practice in the United States, although groundwork for research in the area appears to be developing.

## SECTION VIII

## COSTS, ENERGY AND NONWATER QUALITY ASPECTS

### Introduction

This section deals with the costs associated with the various treatment strategies, available to the secondary aluminum industry, to reduce the pollutant load in the water effluents. In addition, other nonwater quality aspects are discussed. Since the entire secondary industry is engaged in recycling scrap aluminum, it represents significant savings in natural resources, both in terms of aluminum ore (bauxite) and in the reduced pollution and energy consumption represented by a ton of secondary aluminum vs a ton of primary aluminum. These aspects of the industry, therefore, alleviate the nonwater quality environmental impacts identified for each method of control of waste water cited in this section.

Because of the nature of the secondary industry, the cost data obtained are lacking in some details. Often the equipment and operating costs have been combined with other portions of the process. Where data were lacking, engineering estimates were made. All costs are expressed in terms of metric tons. Costs per ton are ten percent higher.

### Basis for Cost Estimation

#### Capital Investment

Where possible, data on equipment costs and total capital were obtained from the secondary aluminum processors. These capital investments were changed to 1971 dollars by the use of the Marshal and Steven's Index (quarterly values of this index appear in the publication Chemical Engineering, McGraw Hill). In addition, where cost data were not available, equipment costs were estimated from published data (Peters and Timmerhaus, 1968). The total capital investment was then calculated as this cost plus:

| | |
|---|---|
| Installation | 50% of equipment. |
| Piping | 31% of equipment. |
| Engineering | 32% of equipment. |
| Electrical Services | 15% of equipment. |
| Contractor's Fee | 5% of equipment. |
| Contingency | 10% of equipment. |

## Operating Costs

The extent of operating cost data available from the secondary processors was usually limited to raw materials and maintenance costs. In order to put all operating costs on a common basis, the following procedure was used to calculate annual operating cost items:

Raw material cost - as reported.
Maintenance - as reported or estimated as 5% of total plant cost.
Depreciation - 10% of the total capital.
Interest - 8% of total capital.
Tax and Insurance - 1% of the plant cost.

## Waste Water From Metal Cooling

### Control Costs

There are esentially two means for effecting waste water control: (1) recycle the cooling water, using a cooling tower to remove the heat in the water, and (2) perform the ingot cooling in air, avoiding the use of water altogether.

In a recycle system, there will be a build up of dissolved solids, and some suspended solids, oil and grease, and sludge. Because of this, a blowdown is carried out about twice a year, typically amounting to 1,000 gal. In present practice, this blowdown is discharged. However, total evaporation is technically feasible for this blowdown.

Conversion of a once-through ingot cooling line to a recirculation system is relatively inexpensive. A capital cost of about $0.43/annual ton of aluminum with an operating cost of $0.15/ton, would be required. Elements in this cost calculation include pumps, settling and slime-settling basin, and the cooling tower. The operating cost does not include savings, resulting from the lowered freshwater use. In order to perform a total evaporation of the blowdown from the cooling tower, a capital cost of $0.30/annual ton, and operating cost of $0.05/ton, would be added to the costs for the recirculation system.

Addition of an air cooling process necessitates longer conveyor lines and the installation of blowers. The cost of the air cooled ingot line relative to the base cost of a once-through cooling system, however, is dependent on whether the plant is to be newly constructed or is existing. In the first case, the smelter is faced with only the difference in initial costs between water cooling equipment and air cooling equipment ($3.1/annual ton). However, the smelter with an existing water-cooled line is essentially faced with an investment for the total air-cooled line ($9.2/ton).

Operating costs for the two cases are air cooling, $2.25/ton, and water cooling, $1.09/ton. Again, no credit has been claimed for the water savings. Another consideration is the fact that an air-cooled ingot line would result in an additional energy consumption of about 11 kwhr/ton.

## Treatment Costs

Water from ingot cooling lines contains large amounts of oil and grease and dissolved solids. The suspended solids content is about 250 to 500 mg/l, approximately half the concentration of the oil and grease and dissolved solids. Treatment of this stream could be done by a separator, which would remove about 75% of the oil and grease (Patterson and Minear, 1971) and probably about 50% of the solids. The equipment consists essentially of a lagoon with a skimming device. This treatment has capital costs of about $0.08/annual ton and $0.07/ton operating costs.

## Cost Benefit

A summary of the cost benefit relationship of control and treatment systems for waste water from metal cooling is shown in Table 27. The data (capital cost) are plotted as Figure 9. Several points can be noted from the data presented in Table 27. No discharge of process waste water pollutants can be achieved by two means, recycle of the cooling water and evaporation of the blowdown from the cooling tower in an evaporator, or the use of air to cool the ingots. Of the two, the recycle scheme is the most economical, requiring a capital outlay of less than $1/annual ton. The one advantage of air cooling is that there is no water use; whereas, water cooling does result in a water consumption of about 55 gal/ton (cooling ingot from 1,500° to 100°F). However, the saving in the cost of water does not justify the use of air cooling to reach no discharge from an economic standpoint. In addition, the energy requirements of an air-cooled line are higher, and the air cooling cannot be used for shot cooling.

In conclusion, it is possible to perform the cooling step and to achieve no discharge of process waste water pollutants, either by recirculation or by air cooling. Costs involved would add about $0.15 to $1.0/ton to the cost of the aluminum produced.

## TABLE 27. COST BENEFIT OF CONTROL AND TREATMENT FOR WASTE WATER FROM METAL COOLING

| | Discharge | | | Costs | |
|---|---|---|---|---|---|
| | Oil and grease kg/ton | Dissolved Solids kg/ton | Suspended Solids kg/ton | Capital; $/annual ton | Operating; $/ton |
| Once-through cooling | 1.2 | 0.12 | 0.63 | 0 | 0 |
| Recycle cooling water | 0.5 | 0.12 | 0.13 | 0.4 | 0.1 |
| Recycle cooling water with evaporation | 0 | 0 | 0 | 0.7 | 0.2 |
| Oil Separation | 0.4 | 0.12 | 0.33 | 0.1 | 0.1 |
| Air Cooling (total) | 0 | 0 | 0 | 9.2 | 2.3 |
| Air Cooling (Δ water) | 0 | 0 | 0 | 3.0 | 1.1 |

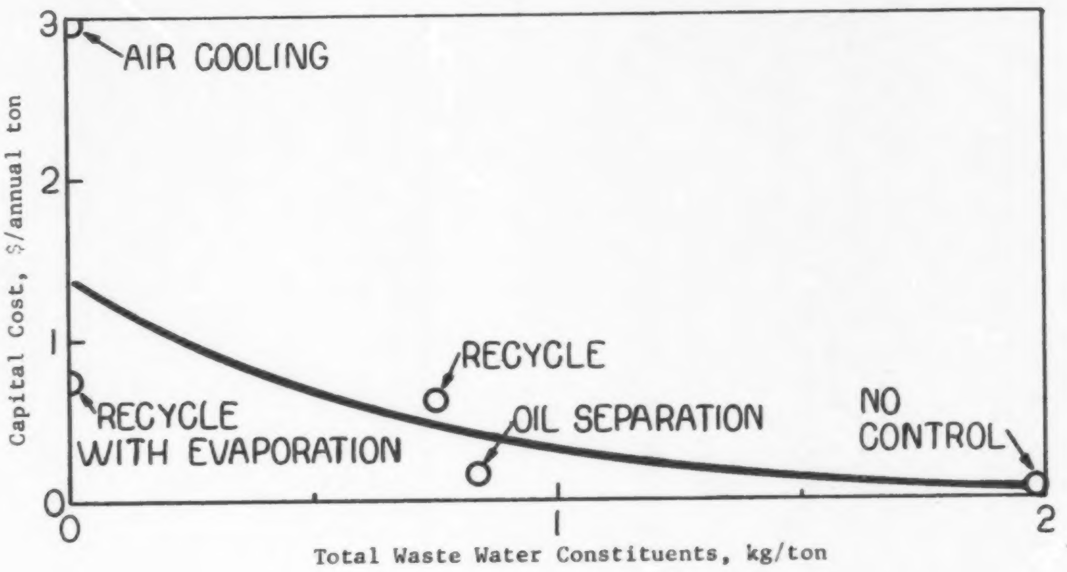

Figure 9. Capital cost for control and treatment of metal cooling water.

## Waste Water From Fume Scrubbing(1)

### Control Costs

The three processes in present use for the control of water effluent are the Derham Process, the Alcoa Process, and the use of $AlF_3$ as a demagging agent.

The equipment cost of the Derham Process was obtained from the licensing company (Andrews, 1973) as between $5,000 and $10,000 for a production rate of 5,000 kkg (5,540 tons) of aluminum/year. The addition of other capital items, installation, piping, etc., adds an average cost of $7,500, and results in a total capital requirement of $3.4/annual ton. The capital equipment includes the molten aluminum pumps, an additional holding furnace, and other items, necessary for conversion of a standard demagging operation to the Derham Process.

The licensing company claims that several cost savings to the secondary smelter would result when the Derham Process is used. The major savings claimed are:

(1) The reported chlorine usage is 3 kg/kg of magnesium removed, in lieu of the value of 3.5 kg/kg found in conventional demagging operations.
(2) An increase in melt rate of 20%.

The operating cost of $2.5/ton, calculated for the Derham Process, includes the savings expected as a result of the two claims above. However, because of the present uncertainty as to whether the Derham process may meet all air pollution control standards, the costs for this alternative have also been calculated for two possible cases of scrubber use. If the Derham process were applied in a small treatment unit (the recommended method), a relatively small volume of gases would need to be scrubbed. This case was calculated on the basis of a caustic scrubber treating 500 actual cubic feet per minute of gases at 150°C (300°F), and gave additional increments of costs amounting to $0.55/annual metric ton capital cost and $0.13/metric ton operating cost. If the backup scrubber for the Derham process treated all the gases (i.e., combustion gases and demagging fume combined), the cost of the larger scrubber would be higher. This case is calculated on the assumption that there are some operational factors, such as lack of space or very stringent air pollution control conditions, that would lead to the use of the scrubber on the combined gases. The conditions assumed for this case were a caustic scrubber, with capacity to treat 11,000 actual cubic feet per minute at 650°C (1200°F), giving a capital cost of $2.23/annual metric ton and an operating cost of $0.54/metric ton (i.e., over and above the costs of the Derham process itself).

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(1) Mention of trade names or specific products does not constitute an endorsement by the Environmental Production Agency

The equipment cost of the Alcoa process was obtained from the licensee (Demmler, 1972). The equipment cost includes the basic reactor, the salt tapping vessel, and the metal tapping vessel. The calculated capital investment, for a 17,000 ton capacity installation, was $5.9/annual ton.

The operating costs were calculated based on information provided by the licensee. These represent a difference between the cost of the Alcoa process and those of the usual fume scrubber operation. The total operating cost was calculated to be $2.9/ton. The Alcoa process is an entirely dry process. No water is used for fume control.

The third method of water control is by the use of a wet scrubbing system in conjunction with AlF3 as the demagging agent. The major advantage of this scrubbing system over a conventional chloride fume scrubber is the ability to recirculate the water used for scrubbing. The fluoride is precipitated with caustic in the recycle loop. As the process is relatively new, there is not enough operating experience to determine whether a small bleed stream would be required. For the purposes of this report, it was assumed that total recycle is being accomplished.

The capital cost of equipment was obtained from the equipment supplier (Waki, 1973) and includes the cost of the scrubber, packed tower, neutralization facilities, thickening tanks, and associated pumps. The total capital required is about $14/annual ton of aluminum. An operating cost of $5.4/ton has been calculated for the AlF3 process. This cost includes the additional expense of using AlF3, rather than chlorine, as the demagging agent.

Costs associated with another control technique for fume control (the "Tesisorb" process) have been calculated, based on data from a fluoride control installation in a glass plant (Teller, 1972). These costs were $27.7/annual metric ton capital and $7.3/metric ton operating. Because of the proprietary nature of the process, the elements involved in this cost estimate have not been given. The technical feasibility of this process applied to fume control in a demagging operation has not been sufficiently established, although it does have the advantage of resulting in no discharge of process waste water pollutants from demagging fume control operations.

## Treatment Costs

The method of treatment of scrubber water, in use at the present time, is neutralization and settling. Costs for this operation are estimated at $2.8/annual metric ton capital and $1.50/ton operating. The equipment cost includes the neutralization facility, settling pond, and associated pumps, piping, controls, etc. The costs of caustic and polyelectrolyte accounts for about

1/3 of the total operating cost to neutralize and settle scrubber water.

### Cost Benefit

A summary of the effluent loadings and costs for the treatment and control models is given in Table 28. The Derham Process gives the best cost benefit. Of the other two dry processes, the Alcoa process is only slightly more expensive; however, the installation of the Tesisorb system would result in higher costs.

## Waste Water from Residue Milling

### Control Costs

At the present time, the only technically feasible means of removing the soluble constituents from this waste is evaporation. The alternative control measure is to perform the residue milling on a dry basis.

The costs for evaporation are dependent on the amount of soluble salts in the residue being milled. The capital cost to evaporate the water from a low salt content residue (dross) is $16/annual metric ton, with operating costs of $24/ton. The major equipment included in the capital cost of evaporation is an evaporator and crystallizer. The heat, required for the evaporation, amounts to about 70 percent of the total operating cost in this cost, assuming a value of $0.50/million Btu. For a residue with high salt content (slag), operating costs would be very high (greater than $300/ton), due to the large amount of heat necessary for evaporation. For economic feasibility, in the case of water discharged from slag wet milling, some means must be used to increase the salt concentration in the water and lower the water use before evaporation can be considered.

### Treatment Costs

Settling treatment in practice has been found to be 99.9+ percent effective in removing the suspended solids. Dissolved solids, however, are not removed at all. Costs reported from one plant were $8.7/annual ton capital, and $3.3/ton operating. Corresponding costs, reported from a second plant, were $15.3/annual ton and $10.9/ton. The reason for the substantial difference in costs between the two plants is related to the amount of water use. In the first plant, the residue is primarily dross, with a low salt content, and consequently, a water use of only 29,000 liters/ton (7,000 gal/ton). However, in the second, the water used for the wet milling operation is 217,000 liters/ton (52,000 gal/ton). This difference is due to

## TABLE 28. COST BENEFIT OF CONTROL AND TREATMENT FOR WASTE WATER FROM FUME SCRUBBING

| Process | Waste Loads, grams/kg $M_\ell$ Removed: Suspended Solids | Dissolved Solids | Al | Mg | pH | Costs: Capital $/Annual ton* | Operating $/ton* |
|---|---|---|---|---|---|---|---|
| Once-Through Scrubbing | 175 | 800 | 50 | 5 | 1.5 | 0 | 0 |
| Neutralize and Settle | ~50 | 500 | 40 | 1.0 | 9.1 | 2.8 | 1.5 |
| $AlF_3$ Process | 0 | 0 | 0 | 0 | - | 14.0 | 5.4 |
| Derham Process | 0 | 0 | 0 | 0 | - | 3.4 | 2.6 |
| Derham Process with small scrubber** | - | - | - | - | - | 3.9 | 2.7 |
| Derham Process with large scrubber** | - | - | - | - | - | 5.6 | 3.1 |
| Alcoa Process | 0 | 0 | 0 | 0 | - | 5.9 | 2.9 |
| Tesisorb (Teller) | 0 | 0 | 0 | 0 | - | 27.7 | 7.3 |

* Ton = metric ton = 2200 lb.

** Insufficient data available to characterize effluents.

the higher salt content of the residue (slag) milled at one of the plants.

### Cost Benefit

The data on cost benefits are presented in Table 29. Control costs to reach no discharge of process waste water pollutants are very high. The only economically feasible method of attaining no discharge of process waste water pollutants is for new sources to install a dry milling operation, in lieu of wet milling. At this point, however, evaporation cannot be ruled out completely, because of the potential to reduce costs by countercurrent milling and selective crystallization of saleable salts. On the other hand, the cost to remove the suspended solids is moderate, and represents less than half the economic burden of evaporation.

## TABLE 29. COST BENEFIT OF CONTROL AND TREATMENT FOR WASTE WATER FROM RESIDUE MILLING

| Process | Waste Loads, kg/ton<br>Suspended Solids | <br>Dissolved Solids | <br>$NH_3$ | Costs<br>Capital $/annual ton* | <br>Operating, $/ton* |
|---|---|---|---|---|---|
| No Treatment | 720 | present | 35 | 0 | 0 |
| Settle | 1.0 | present | 35 | 8.7-15.3 | 3.3-10.9 |
| Settle and Evaporate, Low Flow | 0 | 0 | 0 | 16 | 24 |
| Dry Milling | 0 | 0 | 0 | 130 | -- |

* Metric ton of aluminum produced.

# SECTION IX

## BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE -- EFFLUENT LIMITATIONS GUIDELINES

### Introduction

The effluent limitations, which must be achieved by July 1, 1977, are to specify the degree of effluent reduction attainable through the application of the best practicable control technology currently available. Such control technology is based on the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial category. Because of the absence of data on the characterization of waste water by this industry, the treatment technology and the corresponding effluent limitations are based on a sampling survey of waste waters from exemplary plant operations in this subcategory. Consideration must also be given to:

(a) The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application.
(b) The size and age of equipment and facilities involved.
(c) The processes employed.
(d) The engineering aspects of the application of various types of control techniques.
(e) Process changes.
(f) Nonwater quality environmental impact (including energy requirements).

The best practicable control technology currently available emphasizes treatment facilities at the end of a manufacturing process. It also emphasizes the control technologies within the process itself, when they are considered to be normal practice within the industry. Other technology currently available was considered for its degree of economic and engineering reliability.

### Industry Categorization and Waste Water Streams

The secondary aluminum smelting subcategory is defined as that segment of the aluminum industry which recovers, processes, and remelts various types of aluminum scrap to produce metallic aluminum alloy as a product. Although primary aluminum producers recover captive scrap generated from their own operations, they are not included in this subcategory. The secondary smelters buy scrap in various forms on the open market as their raw material.

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A more useful approach for the purpose of developing effluent limitations guidelines is to deal with the waste water streams themselves. The principal streams are (1) waste water from metal cooling, (2) waste water from fume scrubbing, and (3) waste water from residue milling. Each stream has an associated loading of pollutants per pound of product or scrap processed. For example, the guidelines require a smelter generating only cooling waste water to meet the effluent limitations established for that waste stream. A smelter generating cooling, scrubber, and residue milling waste waters would be required to meet the effluent limitations established for each respective waste water stream.

## Waste Water From Metal Cooling

### Effluent Limitations Based on the Application of the Best Practicable Control Technology Currently Available

The effluent limitations, based on the application of the best practicable control technology currently available, is no discharge of process waste water pollutants into navigable waters.

The achievement of this limitation by use of the control and treatment technologies identified in this document leads to the complete recycle, reuse, or consumption of all water within the process, with an associated result of no discharge of process waste water pollutants.

### Identification of Best Practicable Control Technology Currently Available

The best practicable control technology currently available for metal cooling in the secondary aluminum industry is the elimination of water discharge through the use of the following approaches:

(1) Air cooling of ingots.
(2) Total consumption of cooling water for ingot cooling.
(3) Recycle or reuse of cooling water for deoxidizer-shot cooling or ingot cooling.

With reuse or recycle of water, the need for sludge removal and oil removal will be dictated by plant operational procedures (i.e., the care used in controlling contaminants caused by poor housekeeping). Dissolved salt contamination may be reduced with improved housekeeping and improved manufacturing procedures. Such precautions would provide for an extended period of water reuse, which approaches that of no discharge of process waste water pollutants.

The implemention of the air cooling method or the total evaporation cooling method (the air cooling method with water mist added to assist the air cooling) requires:

(a) The addition of ingot molds to the lengthened conveyor line.
(b) The installation of blowers.
(c) In the case of total evaporation cooling, the addition of special nozzles, flow meters, and controls to existing water lines.

To implement a recycle system for ingot cooling requires:

(a) The addition of a cooling tower, holding tanks, and pumps to the existing water cooling facility.
(b) Provisions for oil and grease removal.
(c) Provisions for sludge removal, dewatering, and disposal.

## Rationale for Selecting the Best Practicable Control Technology Currently Available

Thirty-one of the 58 plants canvassed (or 54 percent) are cooling ingots by one of the methods given above. Existing cooling lines, used for once-through water cooling, could be converted to one of three alternative methods to eliminate the discharge of water. Shot cooling will continue to require direct water cooling and only the last option above, (c), is available to these plants.

Age and Size of Equipment and Facilities. As set forth in this report, general improvements in production concepts have encouraged modernization of plant facilities throughout the industry. This, coupled with similarities of waste water characteristics from metal cooling for plants of varying size, substantiate the identification of total recycle of cooling and/or consumptive cooling as practicable.

Total Cost of Application in Relation to Pollutant Reduction. Based on the information contained in Section VIII of this report, a capital cost of about $0.43/annual metric ton of aluminum alloy would be required to convert an existing once-through cooling systems to a recirculation system. An operating cost of $0.15 per ton would be required, but does not include savings resulting from the lowered fresh water use. Conversion to an air-cooled ingot line from a water-cooled line is estimated to require an investment of $9.2 per ton. Operating costs would be $1.09 per ton, with no credit being claimed for water savings.

Engineering Aspects of Control Technique Application.

This level of technology is practicable, because over 54 percent of the plants in the industry are now achieving effluent reductions by these methods. The concepts are proven, available for implementation, and may be readily adopted by adaptation or modification of existing production units.

Process Changes. This technology is an integral part of the whole cost saving and waste management program now being implemented within the industry. While the application of such technology requires process changes, each has been practiced by existing plants in the industry.

Nonwater Quality Environmental Impact. There are four possible associated impacts upon major nonwater elements of the environment:

(1) An incremental addition to the thermal load of the plant by thermal radiation from air cooling of ingots.
(2) Added electrical energy requirements of about 11 kwhr per ton would be needed for air cooling operations.
(3) Negligible impact on air quality is anticipated from water evaporation either from consumptive water-mist cooling or from sludge drying.
(4) Solid waste disposal of dried sludge would be a minor impact, because of very small amounts accumulated, and its nontoxic character ($Al_2O_3$). Oil and grease, collected during recycled water cooling operations, may be disposed of through responsible waste oil disposal contractors.

## Waste Water From Fume Scrubbing

### Effluent Limitations Based on the Application of the Best Practicable Control Technology Currently Available

The effluent limitations, based on the application of the best practicable control technology currently available, are given in Table 1 for waste water generated during magnesium removal with chlorine. The effluent limitation based on the application of the best practicable control technology currently available is no discharge of process waste water pollutants for waste water generated during magnesium removal with aluminum fluoride.

### Rationale for Effluent Limitations Based on the Application of the Best Practicable Control Technology Currently Available

The values given in Table 1 were derived as follows:

(1) The 30-day average value for total suspended solids is the average of the values given in Table 26 (namely 284 gm/kg and 66 gm/kg) for Cases I and II of Plant C-7. These two values are considered the most representative available. Both of these "after treatment" values are higher than the suspended solids values in the untreated waste. The increase in values during treatment is due to the fine particles of reaction products formed during neutralization, adding to the quantity of suspended solids.
(2) The 30-day average value for chemical oxygen demand is the average of the two values (6.1 and 6.8 grams/kg for

the same effluents (Plant C-7, Cases I and II, Table 26).

(3) The 30-day average ranges of pH given in the limitations are those estimated to provide the optimum conditions for acceptable pH and coprecipitation of both heavy metals, such as copper, and amphoteric elements, such as zinc and aluminum.

## Identification of the Best Practicable Control Technology Currently Available

The best practicable control technology currently available for control of the discharge of pollutants contained in fume scrubber waste water is as follows:

(1) When chlorination is used for magnesium removal, adjustment of the scrubber effluent pH to between 7.5 and 8.5, followed by settling for solids removal. Prior adjustment of the pH of the scrubber liquor, so that the resultant effluent from the scrubber is at a pH of 7.5 to 8.5, followed by settling for solids removal is equally practicable.

(2) When aluminum fluoride is used for magnesium removal, adjustment of the scrubber effluent pH to between 7.5 and 8.5, followed by settling for solids removal. (In practice this treatment is an integral part of the control technology discussed in Section X.) After neutralization and settling, the supernatant is recycled continuously. Solid fluorides are removed continuously.

The fume scrubber water from the chlorine magnesium removal process, upon pH adjustment, cannot be recycled continuously, due to excessive buildup of sodium chloride. Partial recycle of the clarified treated effluent will reduce water consumption.

The use of neutralization and settling treatment, to remove pollutants from chloride scrubber waste water, requires reaction tanks for pH adjustment, mixing tanks for polyelectrolyte addition (if settling is not rapid), a settling tank for solids removal, and associated pumps, controls, and plumbing.

The implementation of continuous recycle of fluoride scrubber waste water will require the additions of liquid storage and pumping capabilities. A chain conveyor for continuous solids removal would also be required.

## Rationale for Selecting the Best Practicable Control Technology Currently Available

Of the 29 plants using wet scrubbing to control air emissions, 20 (or 69 percent) are practicing some form of pH adjustment. Of these 20, 15 (or 51 percent) are removing solids by settling.

The adjustment of pH to 7.5 to 8.5 and settling are effective in removing aluminum and magnesium ions as hydroxides from chloride fume scrubber waste water. Some removal of heavy metals as hydroxides also occurs with the removal of the aluminum and magnesium hydroxides. At a pH of 9.0 or greater, aluminum hydroxide and other amphoteric metal pollutants are dissolved. Therefore, to maximize the overall metal removal, the pH generally should not exceed 8.5. (see discussion, Section VI and Table 26).

An adjustment of pH to 7.5 to 8.5 is effective in reducing the solubility of fluorides by neutralizing the hydrogen fluoride in the effluent. Acid fluoride salts are more soluble than the neutral fluoride salts of the common pollutants in fluoride fume scrubber waste water. The limited solubility of the neutral fluoride salts in water provides a supernatant solution suitable for recycle in scrubber operation.

Age and Size of Equipment and Facilities. Those segments of the industry that are refining aluminum alloys must remove magnesium to attain the specifications of their customers. Therefore, regardless of the size or age of the facility, chemical removal of magnesium is practiced. Control of air emissions from demagging operations with wet scrubbers also is practiced by a majority of the secondary aluminum smelters. Control of the pH and solids content of the effluent from the scrubber is also practiced. In such cases, investments would have to be made for sludge disposal. In a large tonnage secondary smelter, scrubber equipment is used continuously and requires larger treatment facilities than a smaller tonnage plant. A small plant may require treatment capacity for operations lasting only four hours per day. The capital investment for treatment equipment per annual ton would be greater for the smaller plant. However, the similarities in the fume scrubber waste water generated in each type of magnesium removal process (chlorine or aluminum fluoride), regardless of the size or age of the facility, substantiate the level of pollutants that can be removed by pH adjustment and settling.

Those plants using aluminum fluoride for magnesium removal can, by using the same technology, eliminate the discharge of pollutants by adapting the system to completely recycle the supernatant after settling.

Total Cost of Application in Relation to Pollution Reduction. Based on the information contained in Section VIII of the report, a capital cost of about $2.75 per annual metric ton of aluminum alloy produced would be required to install a pH adjustment-settling treatment capability to control pollutant levels from the chloride scrubber systems. An operating cost of $1.5 per metric ton is estimated for such an installation. Lesser capital expenditure would be required by those already neutralizing the scrubber effluent.

For those plants using aluminum fluoride for magnesium removal, treatment of the scrubber waste water requires, in addition to neutralization and settling, a means to recirculate the scrubber water continuously and to continuously remove solids. This would require an estimated capital investment of $9.9 per annual metric ton and an operating cost of $2.45/metric ton.

Engineering Aspects of Control Technique Applications. This technology is practiced by over 51 percent of the plants in the industry to reduce the discharge of pollutants from fume scrubbing operations. The concepts are proven and are available for implementation. They can be adopted to fume scrubbing effluent streams by those presently not using them as an end-of-pipe treatment facility.

Process Changes. The technology of pH adjustment and settling to remove solids is an integral part of the whole waste management program already implemented by part of the industry. All plants in the industry use the same or similar demagging processes, which produce similar discharges. There is no evidence that operation of any current manufacturing process will affect the capability of a plant to implement these end-of-pipe waste treatment technologies.

Nonwater Quality Environmental Impact. There is only one essential impact upon major nonwater elements of the environment. This is the potential effect on soil systems due to the reliance upon the land for ultimate disposition of final solid waste from the treatment. The solid wastes are primarily inorganic and nonleachable. The solid waste from fluoride recovery potentially can affect ground waters adversely and should be disposed of in an acceptable landfill to prevent the contamination of surface or subsurface waters.

Selection of Production Units. Effluent limitations specify the quantity of pollutants which may be discharged from a point source after the application of the best practicable control technology currently available. This quantity must be related to a unit of production, so that the effluent limitations can be broadly applied to various plants in the same subcategory.

The amount of pollutant generated during the chemical removal of magnesium from a given heat is dependent upon the amount of magnesium originally present in the charged scrap and the final magnesium content desired in the metal produced. Judicious selection of scrap entering the melt will reduce this difference, the length of time required for chemical treatment, and the amount of chemical required for reducing the magnesium content to the desired level. These variables in turn establish the amount of material entering the scrubber water. There are variabilities in the amount of magnesium removed for a unit weight of chemical agent. Frequently, these are dependent on the furnace operators' techniques and/or plant practices and, therefore, are not suited for a production unit. An invariant production unit suitable for the determination of pollutant loadings is the amount of magnesium removed relative to the amount of metal produced. This can be determined from the percent magnesium contained in the charge before magnesium removal and the resultant magnesium content.

The application of this guideline requires the reporting of the number of pounds of magnesium removed based on the magnesium content of the melt before magnesium removal, the magnesium content of the product metal, and the net weight of the metal treated for magnesium removal. These data are currently a part of company records. Also required are the flow rate of the discharge water stream from the scrubber system, and the analyses of the pollutants in that stream.

## Waste Water from Residue Milling

### Effluent Limitations Based on the Application of the Best Practicable Control Technology Currently Available

The effluent limitations based on the application of the best practicable control technology currently available is that given in Table 2 in Section II.

### Rationale for Effluent Limitations Based on the Application of the Best Practicable Control Technology Currently Available

The values given in Table 2 were derived as follows:

(1) The 30-day average value for total suspended solids is that reported for Plant D-4 in Table 21. This value is used since it was based on verified, seven to nine month averages of sampling, and is otherwise considered a valid value on the basis of plant operations and raw material variation.

(2) The value for fluoride is derived from data for Plant D-8 in Table 21 and is based on 9 composite samples over a three day period.

(3) The value for ammonia was derived by using the actual concentration of ammonia in the effluent from a plant using exemplary milling practice (0.3 mg/l, Plant D-8, Table 21), and calculating the loading on the associated flow (200 gpm, or 1,090,080 liters/day) and production (37.8 metric tons per day). This use of concentration reflects the chemistry of the reaction during alkaline wet milling. The calculated net loading of ammonia for Plant D-8 in Table 18 is a negative value, that is, the discharge water from the alkaline wet milling operation contained less ammonia than the intake water.

(4) The limitation value for aluminum was derived in the same manner as the ammonia value (i.e., using the concentration of 28 mg/l for Plant D-8 in Table 21).

The same flow and production as in (3) were used, giving a value of 1.0 kg/metric ton of metal recovered.

(5) The values of ammonia, aluminum, copper, and pH are interrelated. The pH specified is to be achieved with reagents other than ammonia. However, if an ammonia loading were not specified, the specified pH value could be present due to a high ammonia content. Further, ammonia and copper interact to form chemical complexes, whose presence would not necessarily be reflected in the measurement of pH. Aluminum is specified to prevent under or over alkalization.

(6) The value of chemical oxygen demand specified is that listed for Plant D-3 in Table 21 (0.97 rounded to 1 kg/metric ton). The source of COD in the effluent has not been fully documented.

## Identification of the Best Practicable Control Technology Currently Available

The best practicable control technology currently available for control of the discharge of pollutants contained in waste water from residue milling is the following:

> A settling treatment of three to four stages, with partial recycle of the sludge and the clear supernatant from the fourth stage to the mill. Adjustment of the intake water pH is necessary to reduce ammonia levels in the waste water during milling.

When milling is done without pH adjustment of the intake water, ammonia remains in solution as a pollutant. To aid the settling of the milling wastes, a polyelectrolyte is frequently added to reduce the level of suspended solids. Recirculation of the sludge in the last settling pond to the mill will reduce the overall sludge content of the final pond.

## Rationale for Selecting the Best Practicable Control Technology Currently Available

Only six of the 23 plants (or 26 percent) processing residues use water for milling. Of these, only three are discharging to navigable waters after treatment in such ponds. The remaining three use total impoundment.

Settling is capable of reducing settleable and suspended solids to very low levels. However, dissolved salts are not removed.

Evaporation and crystallization, although a viable alternative for salt removal, is not currently practiced in the United States. The principal reason is that the cost of salt recovery (for flux cover use) exceeds the price of the salt, even if more concentrated salt solutions were attainable through process changes. The alternative to discharge is total impoundment.

Age and Size of Equipment and Plant. Regardless of the size and age of the facility, the waste water generated from residue milling is similar. All plants are practicing the same type of waste management. Loadings do vary with techniques employed and the amount of molten metal recovered from the operation. Modernization of this segment of the secondary aluminum industry has already reduced the number of smelters processing residues for metal value recovery to 23 plants. Since 17 of the 23 plants process the residues dry, this trend is expected to continue. The life of the equipment in the wet mill is two to three times longer than equipment in dry mills, because of the lower energy requirements needed for comminution.

Total Cost in Relation to Pollution Reduction. Based on the information contained in Section VIII of this document, a capital cost of about $8.7 to $15.3 per annual metric ton of alloy recovered as molten metal and an operating cost of $3.3 to $10.9 per annual metric ton to treat residue waste water by settling is estimated. Variations in the cost are dependent upon (1) the amount of water used for milling and (2) the solids content of the residue.

Engineering Aspects of Control Technique Application. This level of technology is practiced by three of six plants, which process residues by wet methods. The concepts are proven and are reliable for implementation.

Process Changes. Only minor process changes are foreseen. The practice of partial recirculation of the treated effluent is currently used by two plants in the industry.

Nonwater Quality Environmental Impact. There is no added impact upon major nonwater elements of the environment by the adaptation of settling for removal of suspended solids. An impact on soil systems currently exists, due to the reliance upon land for the ultimate disposition of the final solid waste from a wet residue milling operation.

# SECTION X

# BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE -- EFFLUENT LIMITATIONS GUIDELINES

## Introduction

The effluent limitations which must be achieved by July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. This technology can be based on the very best control and treatment technology employed by a specific point source within the industry category or subcategory, or technology that is readily transferable from one industry process to another. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

(a) The age of the equipment and facilities involved.
(b) The process employed.
(c) The engineering aspects of the application of various types of control technologies.
(d) Process changes.
(e) Cost of achieving the effluent reduction resulting from the technology.
(f) Nonwater quality environmental impact (including energy requirements).

The best available technology economically achievable also assesses the availability in all cases of inprocess controls, as well as the control or additional treatment techniques employed at the end of a production process.

A further consideration is the availability of processes and control technology at the pilot plant, semi-works, or other levels, which have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities. Best available technology economically achievable is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation, up to and including no discharge of pollutants. Although economic factors are considered, the costs for this level of control are intended to be top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility. However, best available technology economically achievable may be characterized by some technical risk with respect to performance and with respect to certainty of costs and, thus, may necessitate some industrially sponsored development work prior to its application.

## Waste Water from Metal Cooling

The effluent limitations attainable by the application of the best available technology economically achievable for cooling waste waters is no discharge of process waste water pollutants to navigable waters, as developed in Section IX. The best available technology economically achievable is identical to the best practicable control technology currently available.

## Waste Water from Fume Scrubbing(1)

### Identification of Best Available Technology Economically Achievable

The best available technology economically achievable is the use of inprocess and end-of-process controls and treatment to achieve no discharge of process waste water pollutants into navigable waters. This can be achieved by using one of the following approaches:

(1) The use of currently available processes for fumeless chlorine magnesium removal
(2) Using a combination of $AlF_3$ for demagging and continuous recycling of scrubbing water from emission and effluent control systems
(3) Using a combination of $AlF_3$ for demagging and a coated baghouse system for air pollution control.

Fumeless Chlorine Demagging Processes. The process developed by Derham and the process developed by Alcoa are techniques for removing magnesium from molten aluminum scrap with a minimum of fume generation, through the efficient use of chlorine. No water is used for fume control, but a back-up scrubber may be required with the Derham system.

In the Derham Process a thick cover of fluxing salt over the molten metal almost completely arrests fume emissions and the subsequent need for wet scrubbing for their control. Details of this process are given in Section VII.

The Alcoa process operates on a similar principle, using efficient chlorination of magnesium to minimize emissions. The unit is inserted between the casting line and the furnace and demagging with chlorine takes place as the metal is being cast.

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(1) Mention of trade names or specific products does not constitute an endorsement by the Environmental Production Agency

AlF3 Magnesium Removal with Continuous Recirculation of Scrubber Water. The use of AlF3 for removing magnesium from molten aluminum scrap is advantageous in that it permits fume scrubbing waste water to be continuously recycled. The fluoride salts are relatively insoluble and can be settled out. The same approach for wet scrubbing fumes from chlorine demagging for emission control is not possible, because of the dissolved solids buildup.

AlF3 Magnesium Removal Fume Control With the Coated Baghouse (Teller) Process. In this process fumes from AlF3 magnesium removal are controlled by passing them through chemically treated filters (bags), which remove the pollutants from the exhaust. The system eliminates the use of water for fume control.

## Rationale for Selecting Best Available Technology Economically Achievable

Time Available for Achieving Effluent Limitations. The effluent limitation of no discharge of process waste water pollutants from fume scrubbing is required before July 1, 1983. This allows sufficient time for the planning, purchasing, installation, and trial operation of equipment needed for the three control alternatives identified.

Cost of Achieving the Effluent Limitations. The estimated cost of achieving the effluent limitations from fume emission control will depend on which of the three techniques, given above, is used. The use of the Derham Process for magnesium removal involves an estimated capital expenditure of $3.4 per annual metric ton of capacity and an estimated operating cost of $2.5 per metric ton. The Alcoa Process has been estimated to require a capital cost of $5.9/annual metric ton and an operating cost of $2.9/metric ton (with no credit being taken for selling the magnesium chloride). The use of AlF3 for magnesium removal, combined with continuous recirculation of scrubber water for emission control involves an estimated capital expenditure of $14.0 per annual metric ton and $5.4 per metric ton operating cost. Use of chemically treated baghouse systems (Teller System) for removal of air emission during magnesium removal with AlF3 was similarly estimated to require a capital expenditure of about $27.7 per annual metric ton of capacity and an operating cost of $7.3 per metric ton.

Engineering Aspects of Control Technique Application. The engineering practicability of the Derham Process is demonstrated by its present use in the industry. Currently, the process is under license or is operating at four plants within the U. S. and in four plants outside the U. S. In a telephone canvass of the secondary industry, several plants indicated that they were considering using this process. Both the Derham and Alcoa processes will require extensive research and development efforts to meet their limited capacity (Alcoa) and to reduce their reliance on secondary scrubbers (Derham) to meet air quality standards.

The use of $AlF_3$ for demagging with continuous recirculation of scrubber water is considered achievable because two large plants in the secondary industry are using this technique for emissions and effluent control.

The use of chemically treated baghouses (Teller System) for dry air pollution control during $AlF_3$ demagging is yet unproven from an air quality standpoint. One major plant in the secondary industry has installed the system and is presently evaluating its effectiveness.

*Process Changes*. The application of the Derham Process or the Alcoa Process for magnesium removal would require those plants using $AlF_3$ to change to chlorine and adopt the appropriate procedures and safety measures for its application. No major process changes are anticipated for those already using chlorine.

The use of $AlF_3$ with continuous recycling of scrubber water would require those plants presently using chlorine to change to $AlF_3$ for demagging. This would not involve a major process change, as the application of $AlF_3$ for demagging is simpler than chlorination demagging, but twice as expensive for the removal of the same amount of magnesium. Those plants with low energy, wet scrubbing systems used for chlorine demagging, would need to convert to higher energy systems for effective scrubbing of the fumes generated with the use of $AlF_3$. Although not a principal process change, the change to $AlF_3$ demagging would require extensive modification of present air pollution control equipment now used for collecting fumes from chlorine demagging in some of the larger plants.

The chemically treated baghouse system (Teller System) for dry air pollution control would require those plants using chlorine for demagging to change to $AlF_3$. Those already using $AlF_3$ would have no process change.

*Nonwater Quality Environmental Impact*. The use of the Derham Process results in no known nonwater quality environmental problems. The residues resulting from its application may be too high in soluble salts for economic processing by residue milling techniques for metal recovery and could present a solid waste disposal problem. Insufficient information exists on the process to assess this impact.

Application of $AlF_3$ with continuous scrubber water recirculation could result in a solid waste disposal problem. Fluoride salts precipitated and settled from the scrubbing water are slightly soluble and could possibly be leached in a landfill disposal site.

Application of chemically treated baghouse systems for dry air pollution control also results in a solid waste as the bag coating and the collected dust and fumes may contain fluoride salts that are slightly soluble and leachable to ground water. Disposal of solid wastes in an acceptable landfill is required to prevent contamination of surface or subsurface waters.

## Waste Water from Residue Milling

### Identification of Best Available Technology Economically Achievable

The best available technology economically achievable for waste water from residue milling is the replacement of present wet-milling operations by totally dry milling methods. In dry milling, the residue is crushed and the contained salts, fracturing into small particles, are screened out as undersized waste material. The dry operation is extremely dusty and requires extensive air pollution controls.

Recovery of dissolved salts contained in waste streams from wet milling by evaporation and crystallization is a potential approach to the control or elimination of the discharge of pollutants. The salts can be reused for flux and the condensed water can be recycled back to the milling process. Salt recovery has not been demonstrated in the United States, but is used in Europe.

### Rationale for Selecting the Best Available Technology Economically Achievable

Time Available for Achieving Effluent Limitations. The effluent limitation of no discharge of process waste water pollutants to be achieved July 1, 1983, allows time for the retirement of existing wet milling operations by those plants using this practice.

Cost of Achieving the Effluent Limitations. The cost of achieving no discharge of process waste water pollutants from the milling of residues is estimated to be about $130.00 per annual ton of aluminum production capacity. This is the cost of building a new plant, for the changeover from wet to dry milling involves a complete process change. Data are not available for operating costs, but estimates from the secondary industry indicate such costs to be higher than for wet processing.

The cost of recovery of salts from waste water from residue milling is dependent on the type of residue being processed. The estimated capital cost to evaporate the water from low salt content residues is $16/annual metric ton of aluminum, while operating costs are $24/metric ton. When high salt content residues are processed, the estimated capital costs are $200/annual metric ton and the operating costs are $124/metric ton.

Engineering Aspects of Control Application. Dry processing of residues for aluminum recovery is practical from an engineering standpoint since 15 of the 23 plants processing residues use a totally dry mill operation and generate no associated waste water stream. Thus, the technology is well proven by actual practice.

Process Changes. Plants presently wet milling residues will need to completely alter their presmelter processing facilities to adopt dry milling practices. Crushing, screening, conveying, and dust collection equipment will be required for the conversion.

Nonwater Quality Environmental Impact. Both dry milling and wet milling of residues generates large quantities of solid wastes, ranging from 2.3 to 9 tons per ton of aluminum recovered, depending on the grade of the residue. Generally this solid waste from dry milling contains the highly soluble chloride salts that were washed out during wet milling. Solids should be disposed of in an acceptable landfill to prevent contamination of surface or subsurface waters.

Dry milling also generates large quantities of airborne dust. Appropriate dry collection systems are normally able to control the atmospheric emissions of the dust.

Recovery of salts by evaporation from wet milling waste water is estimated to require additional consumption of thermal energy of 8.6 million kg cal/ton for the low salt residue waste water and 176 million kg cal/metric ton for the high salt residue waste water (on the basis of metric tons of aluminum recovered).

## SECTION XI

## NEW SOURCE PERFORMANCE STANDARDS

### Introduction

The standards of performance, which must be achieved by new sources, are to specify the degree of effluent reduction attainable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives. The added consideration for new sources is the degree of effluent reduction attainable through the use of improved production processes and/or treatment techniques. The term "new source" is defined by the Act to mean "any source, the construction of which is commenced after publication of proposed regulations prescribing a standard of performance."

New source performance standards are based on the best inplant and end-of-process technology identified with additional consideration given to techniques for reducing the discharge of pollutants by changing the production process itself or adopting alternative processes, operating methods, or other alternatives. The standards of performance reflect levels of control achievable through the use of improved production processes (as well as control technology), rather than through a particular type of process or technology, which must be employed. A further determination must be made as to whether a standard permitting no discharge of process waste water pollutants is practicable.

Consideration must also be given to:

(a) The type of process employed and process changes.
(b) Operating methods.
(c) Batch as opposed to continuous operations.
(d) Use of alternative raw materials and mixes of raw materials.
(e) use of dry rather than wet processes (including substitution of recoverable solvents for water).
(f) Recovery of pollutants as byproducts

### Waste Water from Metal Cooling

### Standards of Performance based on the Application of the Best Available Demonstrated Control Technology

The standards of performance to be achieved by new sources is no discharge of process waste water pollutants into navigable waters as developed in Section IX of this document.

### Identification of the Best Available Demonstrated Control Technology, Processes, Operating Methods, or Other Alternatives

The best available demonstrated control technology for metal cooling waste water is identical to the best practicable control technology currently available described in Section IX. The control and treatment technologies identified in Section IX are:

(1) Air cooling of ingots
(2) Total consumption of cooling water for ingot cooling
(3) Recycle or reuse of cooling water for deoxidizer shot cooling or ingot cooling.

## Rationale for the Selection of the Best Available Demonstrated Control Technology

Thirty-one of the existing plants, or 54 percent of the plants canvassed during development of these guidelines, were using the technology identified above and described in Section VII of this document. Thus, the technology is judged to be both available and demonstrated.

A new source has the freedom to design a technology, initially, to achieve the standard of performance without any change in existing equipment. The current practice of these control technologies by a large fraction of the industry demonstrates that there are no significant technical or economic barriers to the selection and implementation of such technology.

The cost of application of the technologies, identified in Section VIII, is estimated to be the same or less for new sources than for existing plants.

## Waste Water from Fume Scrubbing(1)

## Standards of Performance based on the Application of the Best Available Demonstrated Control Technology

The standards of performance to be achieved by new sources discharging to navigable waters are:

1) Identical to the effluent limitations presented in Table 1, Section II, for those plants using chlorine for magnesium removal
2) No discharge of process waste water pollutants for those plants using aluminum fluoride for magnesium removal.

## Identification of the Best Available Demonstrated Control Technology, Processes, Operating Methods, or Other Alternatives

The technology previously identified in Section X as the best available technology economically achievable for control of fumes from chlorine demagging does not meet the criterion of "demonstrated". This technology may not be capable of handling the anticipated capacities of new plants and still permit the control of air contaminants by dry methods. Therefore, the technology previously identified in Section IX as best practicable control technology currently available is considered identical to the best available demonstrated control technology for waste waters from magnesium removal processes.

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### Rationale for Selection of the Best Available Demonstrated Control Technology

The rationale for concluding that the best available demonstrated control technology is identical to the best practicable control technology currently available for waste waters from magnesium removal processes using chlorine is as follows:

(1) Although the technology described in Section X indicates that the Derham and Alcoa processes are able to control fume emissions from chlorine demagging without the use of water, there are some technical limitations to their adoption by new sources. The Alcoa prototypes have been limited to inhouse use for primary aluminum processing and have not been used by the secondary aluminum industry in the United States. In addition, the design may require modification to meet the casting poundage rates presently used by most of the industry. In effect, the system may not be applicable to new sources without further development work.

(2) The Derham process is used by two secondary aluminum smelters in the United States to control fumes generated during the process of magnesium removal with chlorine. One of these plants was not studied and the other was found to be not fully operational. Therefore, it was concluded that insufficient data are available to prove that the system is effective under typical operating conditions. A supplemental wet scrubber may be required with the Derham process to meet air emmissions standards. This is the case for at least one plant in the subcategory. The Derham process is considered insufficiently demonstrated to be applied to new sources without further technical evaluation.

## Waste Water from Residue Milling

### Standards of Performance Based on the Application of the Best Available Demonstrated Control Technology

The standard of performance to be achieved by new sources is no discharge of process waste water pollutants into navigable waters.

### Identification of the Best Available Demonstrated Control Technology, Processes, Operating Methods, or Other Alternatives

The best available demonstrated control technology, processes, operating methods, or other alternatives for residue milling waste water are:

(1) Dry milling, currently in practice in existing plants in the U.S.

(2) The evaporation of waste waters from wet milling of residues with the associated reclamation and reuse of fluxing materials. This technology is not currently demonstrated in any existing plant in the U.S., but is demonstrated in Europe.

The details and costs of these technologies are presented in Sections VII and VIII of this document.

Rationale for Selection of the Best Available Demonstrated Control Technology

The rationale for the selection of the best available demonstrated control technology is as follows:

(1) A new source has the freedom to choose the most advantageous residue processing techniques for maximum recovery of metal and byproducts with the minimum use or discharge of water.
(2) In contrast to an existing source which may have a large capital investment in waste treatment facilities to meet effluent limitations by July 1, 1977, a new source has complete freedom in the selection and design of new waste treatment facilities.
(3) In contrast to an existing source, a new source has freedom of choice with regard to geographic location in seeking any economic advantage relative to power cost or land cost.

Since the technology for achieving no discharge of residue milling waste water has been demonstrated for a facility currently being constructed, it is considered the best available demonstrated control technology for new sources. The possibility of a slightly higher cost in relation to several orders of magnitude reduction in pollution and the possible elimination of monitoring expense for no discharge of effluent warrants the selection of this technology as the best available demonstrated control technology for the secondary aluminum smelting subcategory.

Cost of Achieving No Discharge of Process Waste Water Pollutants. The cost of achieving no discharge of process waste water pollutants from the milling of residues is estimated to be about $130.00 per annual ton of aluminum production capacity. This is essentially the cost of building a new plant. Data are not available for operating costs, but estimates from the secondary industry indicate such costs to be higher than for wet processing.

The cost of recovery of salts from waste water from residue milling is dependent of the type of residue being processed. The estimated capital cost to evaporate the water from low salt content residues is $16/annual ton of aluminum, while operating costs are $24/ton. When high salt-content residues are processed, the estimated capital costs are $200/annual ton and the operating costs are $124/annual ton.

Engineering Aspects of Control Application. Dry processing of residues for aluminum recovery is practical from an engineering standpoint, since 15 of the 23 plants processing residue use a totally dry mill operation and generate no associated waste water stream. Thus, the technology is well proven by actual practice.

# SECTION XII

## ACKNOWLEDGEMENTS

The Environmental Protection Agency would like to thank the staff of the Battelle Memorial Institute (Columbus) under the direction of Mr. John B. Hallowell for their aid in the preparation of this document.

The Project Officer, George S. Thompson, Jr., would like to thank his associates in the Effluent Guidelines Division, namely Mr. Allen Cywin, Mr. Ernst P. Hall, and Mr. Walter J. Hunt for their valuable suggestions and assistance.

Mr. Harry Thron, Effluent Guidelines Division, was responsible for the proposed regulation and development document (October 1973) for this industry.

The members of the working group/steering committee who coordinated the internal EPA review are:

Mr. Walter J. Hunt, Chairman, Effluent Guidelines Division
Mr. Marshall Dick, Office of Research and Development
Mr. John Ciancia, National Environmental Research Center, Edison
Mr. Lew Felleisen, Region III
Mr. Swep Davis, Office of Planning and Evaluation
Mr. Taylor Miller, Office of General Counsel

Appreciation is also extended to the following trade associations and corporations for assistance and cooperation provided in this program:

The Aluminum Recycling Association
Apex Smelting Company
Diversified Materials, Inc.
Newark Processing Company
Rochester Smelting and Refining Company
U. S. Reduction Company
Vulcan Materials Company
Wabash Smelting and Refining Company

Finally, many thanks are given to the hardworking secretarial staff of the Effluent Guidelines Division. In particular, recognition is given to Ms. Linda Rose, Ms. Kaye Starr, and Ms. Nancy Zrubek.

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# SECTION XIV

## GLOSSARY

**Act**

The Federal Water Pollution Control Act Amendments of 1972.

**Alloying**

The process altering the ratio of components in a metal by the addition or removal of such components.

**Borings and Turnings**

Scrap aluminum from machining of castings, rods, bars, and forgings.

**Captive Scrap (Runaround Scrap)**

Aluminum scrap metal retained by fabricator and remelted.

**COD**

Chemical oxygen demand, a parameter used to assess water quality.

**Compatible Pollutants**

Those pollutants which can be adequately treated in publicly owned sewage treatment works without harm to such works.

**Demagging**

Removal of magnesium from aluminum alloys by chemical reaction.

**Dross**

Residues generated during the processing of molten aluminum or aluminum alloys by oxidation in air.

### Effluent

The waste water discharged from a point source to navigable waters.

### Effluent Limitation

A maximum amount per unit of production (or other unit) of each specific constituent of the effluent that is subject to limitations in the discharge from a point source.

### Fluxing Salts (or Covering Flux)

Sodium chloride or a mixture of equal parts of sodium and potassium chlorides containing varying amounts of cryolite. Used to remove and gather contaminants at the surface of molten scrap.

### Heat

A fully charged reverberatory furnace containing aluminum alloy of desired composition.

### Heel

That part of the molten aluminum alloy remaining in the furnace to facilitate melting of scrap being charged for the preparation of the following heat.

### Incompatible Pollutants

Those pollutants which would cause harm to, adversely affect the performance of, or be inadequately treated in publicly owned sewage treatment works.

### Ingots

A mass of aluminum or aluminum alloy shaped for convenience in storage and handling. Sizes according to weight are 15, 30, 50, and 1000 pounds.

Irony Aluminum

High iron content aluminum alloy recovered from old scrap containing iron. Prepared in sweating furnace operating at temperatures sufficiently high to melt only the aluminum.

New Clippings and Forgings

Scrap from industrial manufacturing plants such as aircraft and metal fabricators.

Pigs

Ingots of aluminum alloy weighing 15 to 50 pounds.

Point Source

A single source of water discharge, such as an individual plant.

Pretreatment

Treatment performed on waste waters from any source prior to introduction for joint treatment in publicly owned sewage treatment works.

Residues

Include dross, skimmings and slag recovered from alloy and aluminum melting operations of both the primary and secondary smelters and from foundries.

Reverberatory Furnace (Reverb)

A furnace used for the production of aluminum alloy from aluminum scrap.

Skimmings

Wastes from melting operations removed from the surface of the molten metal. Consists primarily of oxidized metal, but may contain fluxing salts.

**Slag**

Fluxing salts removed from the surface of molten aluminum after charging and mixing. Contains 5 to 10 percent solid aluminum alloy.

**Solids**

Aluminum scrap metal.

**Sows**

Ingots weighing 500 to 1000 pounds.

**Standard of Performance**

A maximum weight discharged per unit of production for each constituent that is subject to limitations and applicable to new sources as opposed to existing sources, which are subject to effluent limitations.

**Sweated Pigs**

Ingots prepared from high iron aluminum alloy.

**Virgin Aluminum**

Aluminum recovered from bauxite.

## TABLE 30. CONVERSION TORS

| Multiply (English Units) |  | by |  | To Obtain (Metric Units) |
|---|---|---|---|---|
| English Unit | Abbreviation | Conversion | Abbreviation | Metric Unit |
| acres | ac | 0.405 | ha | hectares |
| acre-feet | ac ft | 1233.5 | cu m | cubic meters |
| British Thermal Unit | BTU | 0.252 | kg cal | kilogram-calories |
| British Thermal Unit/pound | BTU/lb | 0.555 | kg cal/kg | kilogram calories/kilogram |
| cubic feet/minute | cfm | 0.028 | cu m/min | cubic meters/minute |
| cubic feet/second | cfs | 1.7 | cu m/min | cubic meters/minute |
| cubic feet | cu ft | 0.028 | cu m | cubic meters |
| cubic feet | cu ft | 28.32 | l | liters |
| cubic inches | cu in | 16.39 | cu cm | cubic centimeters |
| degree Fahrenheit | °F | 0.555(°F-32)(a) | °C | degree Centigrade |
| feet | ft | 0.3048 | m | meters |
| gallon | gal | 3.785 | l | liters |
| gallon/minute | gpm | 0.0631 | l/sec | liters/second |
| horsepower | hp | 0.7457 | kw | kilowatts |
| inches | in | 2.54 | cm | centimeters |
| inches of mercury | in Hg | 0.03342 | atm | atmospheres |
| pounds | lb | 0.454 | kg | kilograms |
| million gallons/day | mgd | 3,785 | cu m/day | cubic meters/day |
| mile | mi | 1.609 | km | kilometer |
| pound/square inch (gauge) | psig | (0.06805 psig +1)(a) | atm | atmospheres (absolute) |
| square feet | sq ft | 0.0929 | sq m | square meters |
| square inches | sq in | 6.452 | sq cm | square centimeters |
| tons (short) | ton | 0.907 | kkg | metric tons (1000 kilograms) |
| yard | yd | 0.9144 | m | meters |

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(a) Actual conversion, not a multiplier.

*U.S. GOVERNMENT PRINTING OFFICE:1974 546-318/347 1-3